

Search Results

ArticleTitle Pathogen Risk Assessment Methodology for Municipal Sewage Sludge Landfilling and Surface Disposal (for Microcomputers) (Model-Simulation)

Authors

Journal Environmental Protection Agency, Washington, DC. Office of Research and Development., Mar 96 1 diskette

Abstract Product was developed for assessing the risk to humans of pathogens from disposal of treated municipal sewage sludge. The purpose of the (sludge-only landfill or surface disposal), SLDGFILL model is to determine the probability of infection of a human receptor from pathogens in a sludge-only landfill (monofill) or in a surface disposal site. The ultimate objective for the model is to assist the U.S. Environmental Protection Agency in developing technical criteria for regulatory activities. More immediate objectives include the use of the model to perform actual pathogen risk assessments and to identify research needs.

ArticleTitle Pathogen Risk Assessment Model for Land Application of Municipal Sewage Sludge (LANDAPP Version 4.02) (for Microcomputers)

Authors

Journal Environmental Protection Agency, Washington, DC. Office of Research and Development., Oct 96, 1 diskette, For background, see Volume 1, Methodology, PB90-171901 and Volume II, User's Manual, PB90-171919. See also PB96-501911.

Abstract This model evaluates the potential risk to humans from exposure to pathogenic microorganisms following land application of municipal sewage sludge. The five municipal sewage sludge management practices addressed by the model are: (1) application of liquid sludge for production of commercial crops for human consumption; (2) application of liquid sludge to grazed pasture; (3) application of liquid sludge for production of crops processed for animal consumption; (4) application of dried or composted sludge to residential gardens; and (5) application of dried or composted sludge to residential lawns. The various locations, states or activities in which sludge or sludge-associated pathogens exist are called compartments. They vary to some extent among practices. The computer model represents the compartments and transfers among compartments of the five management practices. In each compartment, pathogens either increase, decrease or remain the same in number with time, as specified by 'process functions' (growth, die-off or no population changes) and 'transfer functions' (movement between compartments). The population in each compartment, therefore, generally varies with time and is determined by a combination of initial pathogen input, 'transfer functions' and 'process functions.'

ArticleTitle Environmental regulations and technology : control of pathogens and vector attraction in sewage sludge (including domestic septage) under 40 CFR part 503.

Authors

Journal Washington, DC : The Office, [1992] viii, 152 p. : ill. (some col.)

Abstract

ArticleTitle Transport of microorganisms through soil.

Authors Abu-Ashour, J.; Joy, D.M.; Lee, H.; Whiteley, H.R.; Zelin, S.

Journal Water-air-soil-pollut. Dordrecht : Kluwer Academic Publishers. May 1994. v. 75 (1/2) p. 141-158.

Abstract

ArticleTitle Modification of hydraulic properties of a semiarid soil in relation to seasonal applications of sewage sludge and electrolyte-producing compounds.

Authors Abu-Sharar T M

Journal Soil Technology 9 (1-2): p 1-13 1996

Abstract A field experiment was carried out to study the effects of sewage sludge and three chemical amendments (gypsum, cement dust, and ground phosphate rock (P.rock)) on volumes of runoff generated from 15 treatment plots, each of 2 times 2 m-2 (three randomized complete blocks each with one control and four treatment plots). The experiment was carried out in the Muaq'qar Experiment Station (Jordan) for five successive winter seasons (87/88 to 91/92). The surface soil (fine, mixed, thermic Typic Calciorthid) was annually mixed to 5 cm depth with sewage sludge (20 tons/ha) or the respective chemical amendment (500 kg/ha) before the beginning of each winter season. The volume of runoff water generated from each plot was measured following rainstorm events of known depth, intensity and duration. Results of multiple linear regression analysis indicated that runoff volume depended mainly on rainfall depth and to a lesser extent on rainfall intensity. Regression coefficient of the runoff-rainfall relation increased and, consequently, structural stability of the soil surface decreased in the following order sewage sludge gt gypsum gt cement dust gt P.rock gt control. In addition, infiltration rate (IR) of the treatment plots decreased in a similar manner. The final IR for the sewage sludge- and gypsum-amended plots was about 10 and 5 times greater than that of the control plots (3.97 +- 0.68 mm h-1), respectively. Decreasing structural stability of the chemically-amended plots conformed to the decreasing solubility of the chemical amendments and, thus, showed the role of electrolyte concentration in preventing surface crust formation. Structural improvement of the sludge-amended plots was due to the increase in both soil salinity and organic matter content.

ArticleTitle Behaviour of alkylphenol polyethoxylate surfactants in the aquatic environment - I. Occurrence and transformation in sewage treatment.

Authors Ahel M; Giger W; Koch M

Journal Water-Research-Oxford. 1994, 28: 5, 1131-1142

Abstract The behaviour of alkylphenol polyethoxylate surfactants in full-scale sewage treatment plants in Switzerland was studied using specific analytical techniques. Parent compounds and the major metabolic products were quantified, Nonylphenol polyethoxylates were efficiently eliminated during biological treatment, but the overall rate of biodegradation was limited due to the formation of refractory metabolites. The abundance of particular metabolites was very dependent on treatment conditions.

ArticleTitle Autoheating and pathogen destruction during storage of dewatered biosolids with minimal mixing.

Authors Ahmed, A.U.; Sorensen, D.L.

Journal Water-environ-res. Alexandria, VA : Water Environment Federation. Jan/Feb 1997. v. 69 (1) p. 81-94.

Abstract

ArticleTitle Kinetics of pathogen destruction during storage of dewatered biosolids.

Journal Water-environ-res. Alexandria, VA : Water Environment Federation. Mar/April 1995. v. 67 (2) p. 143-150.

Abstract

ArticleTitle Short-term leaf surface adhesion of heavy metals following application of sewage sludge to grassland.

Authors Aitken M N

Journal Grass and Forage Science 52 (1): p 73-85 1997

Abstract In the short term, surface-applied, digested, liquid sewage sludge may remain on grass leaf surfaces, leading to enhanced direct intake of potentially toxic elements by stock. The purpose of this field experiment was to investigate metal adhesion to herbage from liquid sewage sludge applications. Liquid digested sludge was applied at 0, 55 or 110 m³ ha⁻¹ to an *Agrostis capillaris* and *Holcus lanatus* sward that had been cut to either 4 cm (short) or 13 cm (long). The application rate of metals was relatively low. One day after application (day 1), 8-13% of the sludge solids applied had adhered to the short grass treatment, accounting for 35-62% of the drymatter (DM) yield. On the long grass, 20-42% of the sludge dry solids adhered, accounting for 46-47% of the herbage DM yield. The content of all heavy metals in and on the grass herbage (Cu, Fe, Ni, Pb, Zn, Cr, Cd) was significantly increased (P < 0.05) at day 1. Cu concentrations in and on the grass decreased to 25 mg kg⁻¹ after 16-29 d, Fe took 33-45 d to decline to 1000 mg kg⁻¹ whereas Pb took 12-18 d to decline to 30 mg kg⁻¹. It took 36 d for Cd, 43 d for Fe, Cu and Ni, and 57 d for Zn and Pb to be not significantly (P > 0.05) different from the control. Grass growth was the most significant factor (P < 0.05 for all treatments and metals) influencing the decline in grass metal concentration, explaining 65-96% of the variation. The cutting treatment, sludge application rate and metal species also significantly affected the extent and rate of reduction in metal contamination over time.

ArticleTitle Response of wheat to sewage sludge applied under two different moisture regimes.

Authors Al-Mustafa, W A; El-Shall, A A; Abdallah, A E; Modaihsh, A S

Journal Experimental Agriculture 31 (3): p 355-359 1995

Abstract A field experiment was conducted from 1989 to 1992 to investigate the effect of sewage sludge applications on wheat yield under different irrigation regimes. The sewage sludge was applied at rates equivalent to 0, 20 or 60 t ha⁻¹ whenever the available soil moisture reached 30 or 70%. The results showed a significant response in grain yield and its nutrient content with no significant differences between rates of sewage sludge applied. Much higher responses were obtained under the wet than under the dry regime.

ArticleTitle Assessment of organic contaminant fate in waste water treatment plants: I: Selected compounds and physicochemical properties.

Authors Alcock R.E. {a}; Sweetman, A; Jones, K.C.

Journal Chemosphere. April, 1999; 38 (10) 2247-2262..

Abstract An extensive and comprehensive literature review has been conducted for compounds which we hypothesise could be present in sludge and maintain their integrity following application to agricultural land. The following compounds have been selected for review; chlorinated paraffins, quinoxaline, brominated diphenyl ethers, polychlorinated naphthalenes, polydimethylsiloxanes, chloronitrobenzenes, and a range of biologically active and pharmaceutical compounds. All have received interest as a result of their persistence and/or toxicity in environmental media. Physicochemical property information has also been compiled and/or calculated. In this way, an accompanying paper will attempt to predict compound fate in waste water treatment plants (WWTPs) and assess likely transfers from soil/plants to grazing livestock. These papers describe a first attempt to predict the fate of these classes of compounds in the environment and prioritise those of greatest concern.

ArticleTitle Assessment of organic contaminant fate in waste water treatment plants. I: Selected compounds and physicochemical properties

Authors Alcock, R E; Sweetman, A; Jones, K C

Journal Chemosphere : (Oxford), 1999 , 38 (10) 2247-2262 No. of Refs.: 3 p.3/4

Abstract An extensive and comprehensive literature review has been conducted for compounds which we hypothesise could be present in sludge and maintain their integrity following application to agricultural land. The following compounds have been selected for review; chlorinated paraffins, quintozone, brominated diphenyl ethers, polychlorinated naphthalenes, polydimethylsiloxanes, chloronitrobenzenes, and a range of biologically active and pharmaceutical compounds. All have received interest as a result of their persistence and/or toxicity in environmental media. Physicochemical property information has also been compiled and/or calculated. In this way, an accompanying paper will attempt to predict compound fate in waste water treatment plants (WWTPs) and assess likely transfers from soil/plants to grazing livestock. These papers describe a first attempt to predict the fate of these classes of compounds in the environment and prioritise those of greatest concern.

ArticleTitle Pentachlorophenol (PCP) and chloranil as PCDD/F sources to sewage sludge and sludge amended soils in the UK.

Authors Alcock, R.E.; Jones, K.C.

Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. Nov 1997. v. 35 (10) p. 2317-2330.

Abstract

ArticleTitle Effect of metal-rich sludge amendments on the soil microbial community.

Authors Baath, E; Diaz-Ravina, M.; Frostegard, A.; Campbell, C.D.

Journal Applied and Environmental Microbiology. 1998, 64: 1, 238-245

Abstract The effects of heavy-metal-containing sewage sludge on the soil microbial community were studied in two agricultural soils of different textures, which had been contaminated separately with Cu, Zn, and Ni at two different levels more than 20 years ago. Three community-based microbiological measurements were compared, namely, phospholipid fatty acid (PLFA) analysis to show changes in species composition, the Biolog system to indicate metabolic fingerprints of microbial communities, and the thymidine incorporation technique to measure bacterial community tolerance. In the Luddington sandy loam soil, bacterial community tolerance increased in all metal treatments compared to an unpolluted-sludge-treated control soil. Community tolerance to specific metals increased the most when the same metal was added to the soil; e.g. tolerance to Cu increased most in Cu-polluted treatments. A dose-response effect was also evident. There were also indications of cotolerance to metals whose concentration had not been elevated by the sludge treatment. The PLFA pattern changed in all metal treatments, but the interpretation was complicated by the soil moisture content, which also affected the results. The Biolog measurements indicated similar effects of metals and moisture to the PLFA measurements, but due to high variation between replicates, no significant differences compared to the uncontaminated control were found. In the Lee Valley silt loam soil, significant increases in community tolerance were found for the high levels of Cu and Zn, while the PLFA pattern was significantly altered for the soils with high levels of Cu, Ni, and Zn. No effects on the Biolog measurements were found in this soil.

ArticleTitle A Study of Toxic Effects of Heavy Metal Contaminants from Sludge-Supplemented Diets on Male Wistar Rats

Authors Bag, S; Vora, T; Ghatak, R; Nilufer, I; D'mello, D; Pereira, L; Pereira, J; Cutinho, C; Rao, V*

Journal Ecotoxicology and Environmental Safety, vol. 42, no. 2, pp. 163-170, Feb 1999

Abstract Activated sludge is a rich source of nitrogenous matter and has been recommended as cheap supplement in animal feed. It has been incorporated into cattle and poultry feed. It is well known that sewage of purely domestic origin is also contaminated with heavy metals, pesticides, and other organic pollutants. A study was undertaken to determine the toxic effects of heavy metal-contaminated domestic sewage sludge on young male Wistar rats by supplementing dehydrated activated sludge in their diet at concentrations of 5, 10, 15 and 20%. The sludge was found to be contaminated with 1.820 (zinc), 0.273 (nickel), 0.017 (lead), 0.053 (copper), 0.006 (chromium), and 0.005 (cadmium)mg/g of dry sludge, by analysis by atomic absorption spectroscopy. The toxic effects of sludge-supplemented diets on individual groups of rats were assessed by assaying various enzyme activities in serum, liver, muscle, and brain. Levels of serum and liver alanine aminotransferase and succinate dehydrogenase (SDH) were significantly low in all the sludge-supplemented diet-fed (SSDF) rats. Similarly, serum lactate dehydrogenase (LDH) and muscle SDH activity were also significantly reduced in the SSDF rats. On the other hand, liver and muscle LDH, serum and liver aspartate aminotransferase, and serum and muscle alkaline phosphatase activities were significantly higher in all the SSDF animals. Brain and muscle acetylcholinesterase activity was significantly high in all the SSDF groups. This study indicates that even though the sludge is a rich source of nitrogenous matter, its supplementation in poultry and animals feed should be done with caution. Otherwise, the contaminants found in the sludge will biomagnify in the food chain and lead to various toxicological hazards.

ArticleTitle Re-use of sewage biosolids on canelands.

Authors Barry, G. A.; Bloesch, P.; Gardner, E. A.; Rayment, G. E.

Journal Proceedings of the 20th conference of the Australian Society of Sugar Cane Technologists held at Ballina, NSW, Australia, 28th April to 1st May 1998. p.69-75

Abstract Results are described from field experiments which investigated the re-use of sewage biosolids on sugarcane on a red earth and a yellow podzolic soil in Queensland, Australia. Crop performance from applications of Nitram were compared with those from biosolid application rates adjusted to be equivalent to the local industry standard of 160 kg N/ha, assuming a 100, 50 or 25% availability of biosolids N. The maximum biosolids rate was 48 dry tonnes/ha. Nitrogen uptake responses occurred for both Nitram and biosolids. However, there was often no yield response to N, particularly in the first year of application due to high background soil N. At one site, yield responses were due to causes other than N nutrition. No depression in CCS was found at the highest application rates of biosolids (760 kg N/ha) and Nitram (240 kg N/ha). Estimates of the relative availability of biosolids N show they were similar in both the year of application and the year following application, with 384 and 325 kg N/ha biosolids N, respectively, required to achieve the same plant N uptake as that obtained from Nitram at 160 kg N/ha. Lysimeter measurements indicated the amount of nitrate N leaching was small, at least for biosolid application rates up to 30 dry t/ha. High application rates up to 48 dry t/ha on the strongly acidic yellow podzolic soil however, showed significant increases in plant Cd, Cu and Zn concentrations. Results from these field trials provide useful indicators of the potential value of biosolids on canelands as well as highlighting some concerns which must be considered to ensure their use is environmentally acceptable.

ArticleTitle Bioavailability of heavy metals in strongly acidic soils treated with exceptional quality biosolids

Authors Basta, NT; Sloan, JJ

Journal Journal of Environmental Quality, vol. 28, no. 2, pp. 633-638, Apr 1999

Abstract Three acidic soils were treated with lime-stabilized biosolids (LS), anaerobic-digested biosolids (AN), or agricultural limestone (L) and incubated at 25 degree C. The soil solution Cd and Zn were AN>LS greater than or equal to L, C. The high application of LS had soil solution Zn equal to that obtained using L. Soil solution Cd and Zn significantly increased at soil pH>5.5 and >5.1, respectively. Soil solution Cd and Zn increases were AN>LS with incubation time. Biosolids treatments increased heavy metal in Ca(NO sub(3)) sub(2) and NaOAc fractions. Except for Cd, most metal from the biosolids were in ethylenediaminetetraacetate and HNO sub(3) fractions.

ArticleTitle The form and bioavailability of non-ionic organic chemicals in sewage sludge-amended agricultural soils

Authors Beck, AJ; Johnson, DL; Jones, KC

Journal Science of the Total Environment, Jun 1996, pp. 125-149, vol. 185, no. 1-3

Abstract The application of sewage sludges to agricultural land may increase the concentrations of many toxic organic chemicals in soils which could have adverse effects on wildlife and human health if these compounds enter foodchains. Chlorobenzenes (CBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs) are amongst those compounds currently receiving most attention. The `form' in which these, and other organic chemicals, are present in soils and their potential to be lost by various processes including leaching, volatilisation and (bio)degradation is shown to be dependent on the physicochemical characteristics of the soil and sewage sludge, environmental conditions and the properties of the chemicals themselves. The distinction is made between those compounds that are labile, reversibly sorbed and irreversibly sorbed by sewage sludge-amended soils. The implications of the form in which the chemicals are present in soil for their `availability' to transfer from the soil to bacteria, fungi, earthworms, grazing livestock and food crops followed by the potential for further transfers, metabolism or bioaccumulation are discussed. The importance of the timing and method of sewage sludge application to soil on `form' and `availability' are also considered.

ArticleTitle Distribution of alkylphenol compounds in Great Lakes sediments, United States and Canada

Authors Bennett, ER; Metcalfe, CD*

Journal Environmental Toxicology and Chemistry, vol. 17, no. 7, pp. 1230-1235, Jul 1998

Abstract Alkylphenol polyethoxylates are a major class of nonionic surfactants that are microbially degraded in sewage treatment plants (STPs) and sediments to more toxic and hydrophobic alkylphenols. Recent data on the estrogenic activity of alkylphenols has prompted interest in the distribution of these compounds in the aquatic environment. Sediment samples were collected from several sites (n = 28) at industrialized and pristine regions of Lake Huron, Lake Erie, and Lake Ontario, USA and Canada, and analyzed for concentrations of 4-nonylphenol (NP) and 4-(tert)-octylphenol (OP). Also, sludge samples were taken from a secondary STP in Whitby, Ontario, Canada. Sediment and sludge samples and analytical standards were prepared for analysis by gas chromatography-mass spectrometry in selected ion mode by combined acetylation and supercritical fluid extraction. Concentrations of NP were up to 37 mu g/g in sediments and >300 mu g/g in the sewage sludge. Concentrations of OP were up to 23 mu g/g in sediment and 21 mu g/g in the sewage sludge. These data indicate that alkylphenols are distributed widely in sediments in the lower Great Lakes. However, concentrations of NP were present at high (mu g/g) levels only in sediments near urban and industrialized centers.

ArticleTitle Review of the environmental occurrence of alkylphenols and alkylphenol ethoxylates

Authors Bennie, DT

Journal Water Quality Research Journal of Canada, vol. 34, no. 1, pp. 79-122, 1999

Abstract Alkylphenol ethoxylates and, in particular, nonylphenol ethoxylates have found many industrial, commercial, institutional and household uses in Canada. These nonionic surfactants are very efficient and cost effective. Their widespread use has led to the detection of the parent surfactants and their degradation products in various environmental matrices. Alkylphenol ethoxylates can be biodegraded aerobically and anaerobically in natural environments and sewage treatment plants. The resulting degradation products are more persistent, more toxic, more lipophilic, less water soluble and more estrogenic than their parent compounds. This article reviews the occurrence of nonylphenol polyethoxylates and their degradation products as well as octylphenol polyethoxylates and their degradation products. There is limited information available about the concentration of these substances in their original product formulations. The highest levels of the degradation products, especially nonylphenol, occur in the anaerobically digested sludge of sewage treatment plants. Sludge from these sewage treatment plants may be used as an amendment to agricultural soils. Various sewage treatment plants have wide ranges of discharged effluent concentrations of these compounds -- some appear to be very efficient at removing alkylphenolics from their effluent stream. Little information is available about the fate of these substances in their receiving environment, and environmental concentrations and bioaccumulation factors of these contaminants in aquatic biota

ArticleTitle Alkylphenol polyethoxylate metabolites in Canadian sewage treatment plant waste streams

Authors Bennie, DT; Sullivan, CA; Lee, H-B; Maguire, RJ

Journal Water Quality Research Journal of Canada, vol. 33, no. 2, pp. 231-252, 1998

Abstract Nonylphenol polyethoxylates and their refractory metabolites, including nonylphenol, are on the second Priority Substances List (PSL2) to determine if they are "toxic" as defined under the Canadian Environmental Protection Act. This study addresses the need for data on their occurrence in raw sewage, final effluents and sludge in Canada. Samples of raw sewage, final effluent and sludge were collected from 16 wastewater treatment plants across Canada in 1995 and 1996. These samples were analyzed for 4-nonylphenol (4-NP), nonylphenol ethoxylate (NP1EO), nonylphenol diethoxylate (NP2EO) and 4-tert-octylphenol (4-t-OP). Measurable quantities of these chemicals were found in almost all raw sewage and sludge samples. In the raw sewage, concentrations ranged from <0.005 to 21 µg/L for 4-t-OP, from 0.69 to 155 µg/L for 4-NP, from 2.9 to 43 µg/L for NP1EO and from 0.26 to 24 µg/L for NP2EO. Sludge concentrations (based on dry weight) ranged from <0.010 to 20 µg/g, from 8.4 to 850 µg/g, from 3.9 to 437 µg/g and from 1.5 to 297 µg/g for 4-t-OP, 4-NP, NP1EO and NP2EO, respectively. Of the final effluent samples, 60% contained detectable amounts of 4-t-OP and concentrations ranged from <0.005 to 0.37 µg/L. Almost all of the final effluent samples had detectable levels of 4-NP, NP1EO and NP2EO. The 4-NP concentrations varied from <0.020 to 13 µg/L, NP1EO was found in the range of 0.072 to 26 µg/L and NP2EO was found in the range of 0.099 to 21 µg/L.

ArticleTitle Occurrence of alkylphenols and alkylphenol mono- and diethoxylates in natural waters of the Laurentian Great Lakes basin and the upper St. Lawrence River

Authors Bennie, DT; Sullivan, CA; Lee, H-B; Peart, TE; Maguire, RJ

Journal Science of the Total Environment, vol. 193, no. 3, pp. 263-275, Jan 1997

Abstract Nonylphenol and its ethoxylates are on the second priority substances list (PSL2) to determine if they are 'toxic' as defined under the Canadian Environmental Protection Act. This study addresses the need for data on their occurrence in surface waters and sediments in Canada. Samples of surface water from 35 sites in the Laurentian Great Lakes basin and the upper St. Lawrence River were analyzed for 4-nonylphenol (4-NP), nonylphenol ethoxylate (NPE sub(1)), nonylphenol diethoxylate (NPE sub(2)) and 4-tert-octylphenol (4-t-OP). Bottom sediment samples from nine heavily industrialized sites were also analyzed for the same chemicals. Measurable quantities of 4-NP and 4-t-OP were found in 24% of all water samples. Values ranged from <0.010 µg to 0.92 µg/l and from <0.005 to 0.084 µg/l for 4-NP and 4-t-OP, respectively. Of the surface water samples, 58% were found to contain NPE sub(1) and 32% contained NPE sub(2). Their concentrations ranged from <0.020 to 7.8 µg/l for NPE sub(1) and from <0.020 to 10 µg/l for NPE sub(2). All nine sediment samples contained 4-nonylphenol, with values ranging from 0.17 to 72 µg/g (dry weight). The majority of sediment samples also contained detectable levels of the other contaminants. A total of 66% of sediments had detectable amounts of NPE sub(1) and concentrations ranged from <0.015 to 38 µg/g (dry weight), 66% of sediments had detectable amounts of NPE sub(2) and values ranged from <0.015 to 6.0 µg/g (dry weight) and 89% of sediment samples had detectable amounts of 4-t-OP and values ranged from <0.010 to 1.8 µg/g (dry weight). The highest concentrations of the analytes found are well below acute toxicity thresholds, but in some cases there may be cause for concern with regard to long-term effects on reproductive health of fish.

ArticleTitle Municipal sludge metal contamination of old-field ecosystems: do liming and tilling affect remediation.

Authors Benninger-Truax, M.; Taylor, D.H.

Journal Environ-toxicol-chem. Tarrytown, N.Y. : Pergamon Press. Oct 1993. v. 12 (10) p. 1931-1943.

Abstract

ArticleTitle Organic micropollutants in Swiss agriculture: distribution of polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) in soil, liquid manure, sewage sludge and compost samples; a comparative study.

Authors Berset, J.D.; Holzer, R.

Journal International Journal of Environmental Analytical Chemistry. 1995, 59: 2-4, 145-165

Abstract The current state of contamination of agricultural soils and manures like sewage sludge, liquid manure and compost in Switzerland with two groups of organic micropollutants: polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) is described. Overall PAH concn for soils ranged between 60-575 µg SIGMA PAH/kg dw (mean value 175 µg/kg dw). The corresponding values for the other matrices were: cattle slurries 87-309 µg/kg (165 µg/kg), pig slurries 66-339 µg/kg (143 µg/kg), sewage sludge 1.7-15 mg/kg (6.3 mg/kg) and compost 0.8-2.7 mg/kg (2 mg/kg). PCB levels for soils averaged 14 µg SIGMA PCB/kg dw and represented typical background concn. PCB values in cattle slurries were slightly higher (20 µg/kg) and significantly higher in pig slurries and compost (37 and 32 µg/kg). The highest PCB concn were found in sewage sludges (0.4 mg/kg). Application of these sludges onto soils at rates normally used in Switzerland (0.5 t dw/ha.per year) does however not represent a serious contamination problem. A qualitative analysis of the environmental samples showed that besides the 16 EPA PAHs frequently used for quantification mainly alkylated derivatives as well as N-S-and-O-PAHs frequently used for quantification were detected. These compounds, although usually found in low quantities, should be considered more seriously when estimating the toxicity of PAHs in the environment.

ArticleTitle Determination of coplanar and ortho substituted PCBs in some sewage sludges of Switzerland using HRGC/ECD and HRGC/MSD.

Authors Berset, J.D.; Holzer, R.

Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. June 1996. v. 32 (12) p. 2317-2333.

Abstract

ArticleTitle Toxicity, uptake and metabolism of 4-n-nonylphenol in root cultures and intact plants under septic and aseptic conditions.

Authors Bokern, M.; Raid, P.; Harms, H.

Journal Environmental Science and Pollution Research International. 1998, 5: 1, 21-27

Abstract 4-Nonylphenol (4-n-NP), a compound with oestrogenic activity, has been shown to occur in sewage sludges and effluents of sludge treatment. This, as well as its use in the formulation of pesticides, may result in the contamination of crop plants which could affect the quality of food or feedstuff. The toxicity, uptake and metabolism of 4-n-NP (as [¹⁴C]4-n-NP) were investigated in root cultures of *Lupinus polyphyllus* and *L. hartwegii* under septic and aseptic conditions and with intact plants (tomatoes, wheat and *Atriplex hortensis*) grown in containers with soil or aseptically grown in nutrient media. 4-n-NP was toxic to all plant systems tested. The presence of microorganisms (*Bacillus benzoevorans* and *Pseudomonas fluorescens*) and the developmental state of the plant material appeared to influence the EC₅₀ values. 4-n-NP was taken up by roots. Metabolism to polar compounds was observed in cases with sufficiently high uptake rates. In intact plants, transport from roots to shoots was evident. Metabolism in roots changed quantitatively in the presence of microorganisms. The mineralization of 4-n-NP to ¹⁴CO₂ only occurred with microorganisms.

ArticleTitle The use of soluble organic polymers in waste treatment

Authors Bolto, BA; Dixon, DR; Gray, SR; Chee, Ha; Harbour, PJ; Ngoc, Le; Ware, AJ

Journal WATER QUALITY INTERNATIONAL '96. PART 5: INNOVATIVE TREATMENT TECHNOLOGIES; MEMBRANE TECHNOLOGY., 1996, pp. 117-124, Water Science and Technology, vol. 34, no. 9

Abstract Organic polymeric flocculants have been used in water purification for several decades as coagulant aids or floc builders, after the addition of inorganic coagulants like alum, iron salts or lime. The increased use of cationic polyelectrolytes as primary coagulants instead of inorganic salts, which has occurred in recent times, arises from their significant inherent advantages. The main ones are faster processing, a lower content of insoluble solids to handle, whether by sedimentation, filtration, flotation or in biological conversion, and a much smaller sludge volume. Polymers have often been used in chemically assisted sedimentation of sewage solids to enhance the removal of suspended matter. The concept is applicable as well to the primary coagulation of industrial wastewaters where the separation may be based on flotation, as in examples from the leather, steel, wool scouring, cosmetic, detergent, plastics, dyehouse, paper, food processing and brewing industries. A cationic polymer of particular charge density is optimal, and hydrophobically modified polymers have relevance in the case of oil and grease removal. The burden of solids which must be floated is much reduced relative to systems utilising inorganic coagulants, and the dosage of chemicals overall is lower. In some cases the addition of some inorganic coagulant is unavoidable, as in the case of highly coloured effluents; in others, an anionic surfactant is needed to facilitate flotation.

ArticleTitle Radiation processing of sewage and sludge. A review

Authors Borrely, SI; Cruz, AC; Del Mastro, NL; Sampa, MHO; Somessari, ES

Journal Progress in Nuclear Energy, vol. 33, no. 1-2, pp. 3-21, 1998

Abstract This paper describes the potential of using ionizing radiation to disinfect sewage and sludge, as well as the possibilities of recycling natural resources and their by-products. Presented here is a brief review on the development of radiolytic treatment of wastewaters with electron beam accelerators or super(60)Co gamma sources to eliminate organic and biological contaminants from liquid and solid wastes. Suitable radiation doses are suggested for each particular case.

ArticleTitle The use of microbial parameters in monitoring soil pollution by heavy metals.

Authors Brookes, P. C.

Journal Biology and Fertility of Soils vol. 19 (4): p.269-279, 1995

Abstract Microbial parameters appear useful in monitoring soil pollution by heavy metals, but no single microbial parameter can be used universally. Microbial activities such as respiration, C and N mineralization, biological N₂ fixation, and some soil enzymes can be measured, as can the total soil microbial biomass. Combining microbial activity and population measurements (e.g. biomass-specific respiration) appears to provide more sensitive indications of soil pollution by heavy metals than either activity or population measurements alone. Parameters that have some form of 'internal control', e.g. biomass as a percentage of soil organic matter, are also advantageous. By using such approaches it might be possible to determine whether the natural ecosystem is being altered by pollutants without recourse to expensive and long-running field experiments. However, more data are needed before this will be possible. New applications of molecular biology to soil pollution studies (e.g. genetic fingerprinting) are also considered.

ArticleTitle The phytoavailability of cadmium to lettuce in long-term biosolids-amended soils.

Authors Brown, S.L.; Chaney, R.L.; Angle, J.S.; Ryan, J.A.

Journal Journal of Environmental Quality. 1998, 27: 5, 1071-1078

Abstract A field study was conducted in Maryland, USA, to assess the phytoavailability of Cd in long-term biosolids-amended plots managed at high and low pH. The experiment, established 13 to 15 years prior to the present cropping, on a fine sandy loam soil (clayey Typic Paleudult) used a variety of biosolids. Two of the biosolids had total Cd concentrations of 13.4 and 210 mg/kg. A Cd salt treatment, with Cd added to soil at a rate equivalent to the Cd added by the higher Cd biosolids applied at 100 t/ha, was also included. The lettuce (*Lactuca sativa* var. *longifolia* cv Paris Island Cos) used in the initial study was also used in the current study. Lettuce Cd was compared between treatments, and in relation to the soil Cd:soil organic C (OC) ratio. There was no significant increase in plant Cd since the initial cropping. With 16% of the biosolids added OC remaining, lettuce grown on the soil amended with the more contaminated biosolids was not different than that of the initial cropping. Significantly less Cd was taken up by lettuce grown on biosolids-amended soil than lettuce grown on soil amended with equivalent rates of Cd salt. The Cd concentration in lettuce grown in the low Cd biosolids treatment was not different from the control. These results indicate that the potential hazards associated with food chain transfer of biosolids-applied Cd are substantially lower than equivalent Cd salt treatments, and that the hazards do not increase over time.

ArticleTitle Relative uptake of cadmium by garden vegetables and fruits grown on long-term biosolid-amended soils

Authors Brown, S.L.; Chaney, R.L.; Lloyd, C.A.; Angle, J.S.; Ryan, J.A.

Journal Environmental Science and Technology, vol. 30, no. 12, pp. 3508-3511, Dec 1996

Abstract Cadmium contamination of soils has been viewed as the most dangerous form of trace element contamination of soil. The primary risk posed by Cd contamination is through the ingestion of vegetables grown on Cd-contaminated soil. A variety of garden vegetables selected as representatives of the major food groups were grown on long-term sludge and control plots at high and low pH levels to determine their patterns of Cd uptake in reference to an indicator crop. This was done to determine the potential for a relative uptake index. This relative uptake index (RUI) can be used to assess the risk potential for transfer of soil Cd to the food chain for contaminated sites. Lettuce (*Lactuca sativa*) was used as the indicator crop. For all vegetables excluding dry bean (*Phaseolus vulgaris*), which shows very low Cd uptake, it was possible to define a statistically significant log linear relationship with Cd accumulation in lettuce. When only the more contaminated treatments were included, a more quantitative relation between Cd in the indicator crop and Cd in the other vegetables (including bean) was defined. This indicates that a RUI may be appropriate for risk evaluation on more heavily Cd-contaminated soils.

ArticleTitle Correction of limed-biosolid induced manganese deficiency on a long-term field experiment

Authors Brown, Sally ; Angle, J. S; Chaney, R. L

Journal Journal of Environmental Quality v. 26 (Sept./Oct. '97) p. 1375-84

Abstract To correct deficiencies observed on a long-term biosolid research experiment in Beltsville, Maryland, that had been established on a Galestown sand in 1976 with lime-stabilized biosolids applied at 224 and 448 Mg/ha-1, a randomized complete block experiment was set up in plot areas of the original study. Soil amendments incorporated MnO at 50, 100, and 200 kg/ha-1 and MnSO₄ at 200 kg/ha-1. The results are discussed in detail.

ArticleTitle Cadmium in the food chain: A review.

Authors Burgat-Sacaze, V; Craste, L; Guerre, P

Journal Revue de Medecine Veterinaire, vol. 147, no. 10, pp. 671-680, Oct 1996

Abstract Excessive accumulation of cadmium (Cd) in man is associated with various toxic effects like renal dysfunction and osteomalacia. It is now generally accepted that environmental sources of Cd are increasing and this review gives a general pattern of Cd translocation in the human food chain. In the aquatic environment Cd can be transferred, without biomagnification, in aquatic plants, molluscs and crustaceans. The extent of Cd uptake by plants is highly positively correlated to Cd soil concentrations. Cd retention in tissues of farm animals demonstrates that the liver and kidneys Cd concentrations are correlated to the environmental Cd contamination. Thus, the various potential hazard, like the sewage sludge amendments, must be evaluated. For the general population, the main exposure to Cd is via food and vegetable products (cereals, bulb crops, leafy vegetables). The results from the French surveys on trace elements in animals tissues demonstrate that cattle and swine liver Cd concentrations are lower than 0,5 ppm. These data are compared to those obtained in other countries. Dietary intake of Cd in France is estimated to be lesser than the maximum allowed level (1 μ g/kg b.w./day), but other studies are necessary to estimate the human exposure.

ArticleTitle Quality of runoff from plots treated with municipal sludge and horse bedding

Authors BUSHEE E L; EDWARDS D R; MOORE P A JR

Journal Transactions of the ASAE, 1998 , 41 (4) 1035-1041

Abstract Land application of horse stall bedding and municipal sludge can increase runoff concentrations of nutrients, organic matter, and bacteria as well as steroidal hormones such as estrogen. Concentrations of materials in runoff from sites treated with animal manure can be reduced by aluminum sulfate, or alum (Al SUB 2 (SO SUB 4) SUB 3 .14H SUB 2 O) treatment. The objectives of this study were to assess plots treated with horse stall bedding or municipal sludge for: (a) runoff quality (concentrations of nitrate nitrogen (NO SUB 3 -N), ammonia nitrogen (NH SUB 3 -N), orthophosphate-phosphorus (PO SUB 4 -P), fecal coliform (FC), chemical oxygen demand (COD) and 17- beta estradiol (17 beta -E, a form of estrogen)); (b) changes in runoff quality caused by alum treatment; and (c) time variations in concentrations of the analysis parameters. Horse bedding and municipal sludge were applied to twelve 2.4 x6.1 m fescue plots (six each for the bedding and sludge). Three of the bedding-treated and three of the sludge-treated plots were also treated with alum. Simulated rainfall (64 mm/h) was applied to the 12 treated plots and to three control (no treatment) plots. The data were analyzed as originating from separate completely randomized, one-way designs with three replications of each treatment. The first design had treatment levels of bedding, bedding and sludge, and control, while the second design had treatment levels of sludge, sludge and alum, and control. The control data were common to both designs. The first 0.5 h runoff was sampled and analyzed for the parameters described above. Analysis parameter concentrations for the waste treated plots were generally lower than those previously reported for runoff after organic treatment. In some cases, concentrations were no different from the controls. Mass losses of all parameters were low and agronomically insignificant. Alum addition decreased runoff PO SUB 4 -P concentrations and increased NO SUB 3 -N concentrations but had no effect on concentrations of other parameters. A significant effect of alum addition on 17 beta -E and COD concentrations was anticipated on the basis of previous studies; its absence might have been due to inadequate mixing or interval between addition and simulated rainfall. Relationships between concentration and collection time followed two patterns: (a) highest concentrations occurring during the first sample (two minutes following runoff initiation; NO SUB 3 -N, COD, FC and 17 beta -E) and (b) delay in peak concentration until four minutes following runoff initiation (NH SUB 3 -N and PO SUB 4 -P). The detection of different general relationships between concentration and time suggests that different mechanisms are dominant in transport of the parameters analyzed.

ArticleTitle Direct toxicity assessment of two soils amended with sewage sludge contaminated with heavy metals using a protozoan (*Colpoda steinii*) bioassay.

Authors Campbell, C.D.; Warren, A.; Cameron, C.M.; Hope, S.J.

Journal Chemosphere. 1997, 34: 3, 501-514.

Abstract A rapid bioassay involving growth of the common soil ciliate *Colpoda steinii* was used to study the toxicity and bioavailability of heavy metals in soil solutions extracted from air-dried soils from two long-term experiments that were amended with sewage sludge. The sludges were predominantly contaminated with either Ni, Cu, or Zn. Growth of *C. steinii* was strongly inhibited in all the metal-amended soils compared with the equivalent unamended control soils. The bioassay responses were regressed with metal concentrations in soil and soil pore water to relate the biological response to heavy metal regulatory limits for soils receiving sewage sludges.

ArticleTitle Chemical extractability and availability of heavy metals after seven years application of organic wastes to a citrus soil

Authors Canet, R.; Pomares, E.; Tarazona, E.

Journal Soil use and management, 1997 , 13 (3) 117-121

Abstract The chemical extractability of heavy metals introduced into the soil during 7 years application of sewage sludge, composted municipal solid waste and sheep manure, and their availability to citrus plants were studied. The total content of metals in the soil (0-20 cm) was increased by the use of sludges and compost, but only the Ni content in the saturation extracts of soil was significantly increased. Total Cd, Cr, Cu, Ni, Pb, and Zn were sequentially fractionated into water-soluble plus exchangeable, organically bound, carbonate-associated, and residual fractions. Most of the heavy metals were present in carbonate and residual fractions, although substantial amounts of water-soluble plus exchangeable Cd, and organically bound Cu and Ni were found. No significant increases in the metal contents in leaves and orange fruits were observed, with the exception of Pb in leaves. Several statistically significant correlations between metal content in plants, metal content in soil fractions, and chemical characteristics of soil were also found.

ArticleTitle Methyl mercury contamination and emission to the atmosphere from soil amended with municipal sewage sludge

Authors Carpi, A.; Lindberg, S.E.; Prestbo, E.M.; Bloom, N.S.

Journal Journal of Environmental Quality, vol. 26, no. 6, pp. 1650-1655, Dec 1997

Abstract In an effort to identify the effect of municipal sewage sludge application on mercury (Hg) concentrations in soil, we studied the contamination of sludge-amended soil with inorganic and methyl Hg and the emission of these contaminants to the atmosphere using a Teflon dynamic flux chamber. The routine application of municipal sewage sludge to cropland significantly increased both total and methyl Hg in surface soil from 80 to 6100 $\mu\text{g}/\text{kg}$ and 0.3 to 8.3 $\mu\text{g}/\text{kg}$, respectively. Both inorganic and methyl Hg were transported from the sludge/soil matrix to the environment by emission to the atmosphere, however, there was no indication of Hg transport in limited soil water lysimeter experiments. Our data from soil amended with municipal sewage sludge represent the first quantitatively measured terrestrial source of methyl mercury (MeHg) to the atmosphere. Sludge-amended soil emitted an average of 12 to 24 pg/m^2 of monomethyl Hg and similar to 100 ng/m^2 of inorganic Hg to the atmosphere. A simple dispersion model suggests that sludge-amended soil may increase regional atmospheric MeHg concentrations by similar to 5%. These data highlight the need for further research to quantify the transport of Hg from sludge-amended soil and identify the sources of MeHg in the atmosphere.

ArticleTitle Methyl mercury contamination and emission to the atmosphere from soil amended with municipal sewage sludge.

Journal Journal of Environmental Quality. 1997, 26: 6, 1650-1655; 43 ref.

Abstract The effect of municipal sewage sludge application on mercury (Hg) concentrations in soil was investigated in a study of the contamination of sludge-amended soil with inorganic and methyl Hg and the emission of these contaminants to the atmosphere using a Teflon dynamic flux chamber. The routine application of municipal sewage sludge to cropland at four sites in Tennessee, USA, significantly increased both total and methyl Hg in surface soil from 80 to 6100 $\mu\text{g}/\text{kg}$ and 0.3 to 8.3 $\mu\text{g}/\text{kg}$, respectively. Both inorganic and methyl Hg were transported from the sludge/soil matrix to the environment by emission to the atmosphere; however, there was no indication of Hg transport in limited soil water lysimeter experiments. The data from soil amended with municipal sewage sludge represent the first quantitatively measured terrestrial source of methylmercury (MeHg) to the atmosphere. Sludge-amended soil emitted an average of 12 to 24 pg/m^2 per h of monomethyl Hg and \sim 100 ng/m^2 per h of inorganic Hg to the atmosphere. A simple dispersion model suggests that sludge-amended soil may increase regional atmospheric MeHg concentrations by \sim 5%.

ArticleTitle Seasonal trends in soil nitrogen from injected or surface-incorporated sewage sludge applied to corn.

Authors Cartron Juliet M; Weil Ray R

Journal Communications in Soil Science and Plant Analysis 29 (1-2): p 121-139 Jan., 1998

Abstract Use of sewage sludge on cropland may contribute to nitrate leaching or runoff from fields if mineralization of organic nitrogen (N) is not in synchrony with crop N uptake. Differences in sludge application method may influence sludge N use efficiency. A two-year field experiment was conducted to determine how method of applying lime-stabilized digested sewage sludge in the spring affected seasonal patterns of soil mineral N. Sludge rate was such as to supply 157 kg ha⁻¹ plant available N as determined by State of Maryland regulations. Corn (*Zea mays*) yield in year 2 and corn earleaf N at tasseling in both years were significantly lower for surface-incorporated sludge than for injected sludge, although equivalent N was applied to both. Vertical distribution of soil ammonium-N and nitrate-N within the surface 30 cm of soil in year 2 suggested that, compared to injected sludge, surface-incorporated sludge lost more nitrate by leaching before the period of rapid plant N uptake. Release of nitrate was delayed by at least one month with injected as compared to surface-incorporated sludge. In both years, soil pH and electrical conductivity measured about one month after sludge application were sufficiently high to inhibit nitrification in the injected sludge band. Residual mineral soil N remaining in the upper 30 cm of soil after plant N uptake ceased in fall was greatest with injected sludge in both years. Delayed nitrification in the injected band should be considered in planning, method and timing of sludge applications to cropland.

ArticleTitle Environmental monitoring of surfactants in Europe carried out by AIS/CESIO. Results relevant to alkylbenzene sulfonate (LAS). > OT: Monitoraggio ambientale di tensioattivi in Europa condotto da AIS/CESIO. Risultati relativi al linear alchilbenzene solfonato (LAS).

Authors Cassani, G.

Journal Rivista Italiana delle Sostanze Grasse. 1995, 72: 12, 545-548; 7 ref.

Abstract Studies carried out on activated sewage sludge treatment plants in Germany, UK, Netherlands, Spain and Italy showed that 92.2% of the alkylbenzene sulfonate (LAS) was removed from the liquors of the plants. Only small amounts of LAS were discharged into rivers and 0.49-5.3 micro g/g were found in sediments below the plants.

ArticleTitle Effect of liquid sewage sludge addition on atrazine sorption and desorption by soil.

Authors Celis, R.; Barriuso, E.; Houot, S.

Journal Chemosphere. 1998, 37: 6, 1091-1107; 30 ref.

Abstract Liquid sewage sludge (LSS) addition to soil incorporates both insoluble suspended organic material and large amounts of dissolved organic matter (LSSDOM) which can influence the sorption-desorption behaviour of pesticides by soil constituents. Batch sorption isotherm techniques were used to determine the relative effect of the insoluble and dissolved organic matter from a LSS on the sorption and desorption of the herbicide atrazine by soil. Atrazine sorption and desorption isotherms were obtained on soil, LSS, LSS-amended soil, and LSSDOM-pretreated soil and described by the Freundlich equation. The overall effect of LSS addition to soil (insoluble and dissolved organic matter) was to increase atrazine sorption, due to the high sorption capacity of the added insoluble organic matter. In contrast, LSSDOM, which was mainly constituted by low molecular weight molecules, decreased atrazine sorption by the soil. No evidences for stable interactions in solution between LSSDOM and atrazine were found, thus suggesting processes taking place at the soil/solution interface, such as competition for sorption sites on the soil surface, are the main ones responsible for the observed decrease in atrazine sorption by LSSDOM. Desorption of atrazine from soil was also enhanced by LSSDOM, but this effect was highly reduced when the soil had been pretreated with LSS (insoluble and soluble organic matter) or with LSSDOM alone. In these cases, interactions of LSSDOM with the soil surface had already taken place before the desorption experiment and the LSSDOM effects during desorption were less evident. The results of this work suggest that LSSDOM applied to soils may enhance the risk of groundwater contamination by promoting atrazine desorption from soil, especially when the soil surfaces are free of LSSDOM.

ArticleTitle Microbial biomass dynamics during the decomposition of glucose and maize in metal-contaminated and non-contaminated soils.

Authors Chander, K.; Brookes, P.C.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. 1991. v. 23 (10) p. 917-925.

Abstract Metal-contaminated soils (produced by past long-term applications of contaminated sewage-sludge) from the Woburn Market Garden Field Experiment were previously shown to contain only about half the amounts of microbial biomass as other soils from the experiment which received farmyard manure during the same period. In some cases, the amounts of biomass in the metal-contaminated soils were even smaller than in other soils from the experiment which received inorganic fertilizer throughout. It is possible that the metals were causing decreased efficiency of substrate utilization by the microbial biomass, leading, in turn, to a smaller microbial population. This was investigated in a laboratory experiment by adding ¹⁴C-labelled glucose and ¹⁴C-labelled maize shoots (maize) separately to a metal-contaminated and a non-contaminated soil from the field experiment. Microbial biomass C, ninhydrin-N, soil ATP content and CO₂ evolution were measured during the next 50 days following glucose addition and 100 days following maize addition in both soils. The biomass formed following addition of glucose or maize was consistently smaller in the metal-contaminated soil throughout the incubations. Overall, about 15-32% less glucose-derived and 25-60% less maize-derived biomass was formed in the metal-contaminated soil. In contrast, more CO₂-C was evolved from the metal-contaminated soil than from the non-contaminated soil. This suggests that the biomass in the metal-contaminated soil was less efficient in the utilization of substrates for biomass synthesis. It is suggested that this may be a major reason for the smaller biomass in the metal-contaminated Woburn soils.

ArticleTitle Effects of heavy metals from past application of sewage sludge on microbial biomass and organic matter accumulation in a sandy loam and silty loam U.K. soil.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. 1991. v. 23 (10) p. 927-932.

Abstract Amounts of microbial biomass were measured in soils from two different U.K. field experiments, one on a sandy loam (15% clay) at Luddington (Wick series) and the other on a silty loam soil (21% clay) at Lee Valley (Hamble series), where sewage sludges, mainly enriched with single metals, were applied 22 yr ago. No single metal (Zn, Cu, Ni and Cd) at or below current EC permitted total soil metal concentrations, or limits, decreased the amounts of soil microbial biomass. However, Cu at about two and a half times permitted metal limits decreased the amounts of biomass by about 40% at both sites and caused an increased accumulation of organic C and total N of about 30% in the sandy loam and about 13% in the silty loam soil. Zinc, at about the same concentration, decreased the biomass by about 40% in the sandy loam and 30% in the silty loam soil while soil organic matter accumulation increased by only 9-14%. Cadmium, at about twice current EC limits did not affect the amount of biomass or soil organic matter in the silty loam-soil. Similarly, neither were affected by Ni at 2-3 times current metal limits. The amount of microbial biomass C as a percentage of total soil organic C was much lower (< 1.0%) in soils contaminated with Zn and Cu at about two-and-a-half times current permitted limits than in soils containing less metal. This also suggested that the metals were causing decreased microbial biomass at these metal concentrations.

ArticleTitle Organic contaminants in municipal biosolids: Risk assessment, quantitative pathways analysis, and current research priorities

Authors Chaney, R.L.; Ryan, J.A.; O'Connor, G.A.

Journal ORGANIC CONTAMINANTS IN SEWAGE SLUDGES., Jun 1996, pp. 187-216, Science of the Total Environment, vol. 185, no. 1-3

Abstract Basic research and monitoring of the fate and potential effects of PCBs and other xenobiotic organics in biosolids (municipal sewage sludge) used on cropland have identified specific Pathways by which the xenobiotic organics in biosolids can reach and cause exposure to humans, livestock, plants, soil biota, wildlife, etc. In order to provide the scientific basis for the Clean Water Act Regulations (40 CFR 503) on land application of biosolids in the U.S., a Pathway Approach to risk assessment was undertaken. Pathways included general food production; garden food production; soil ingestion by humans, livestock, and wildlife; human exposure through livestock tissues where the livestock were exposed through crop contamination or biosolids/soil ingestion; wildlife exposure through soil organisms; release to surface and groundwater; volatilization into inhaled air, or dust generated by tillage. Two Pathways were found to comprise the greatest risk from persistent lipophilic organic compounds such as PCBs: (1) adherence of biosolids to forage/pasture crops from surface application of fluid biosolids, followed by grazing and ingestion of biosolids by livestock used as human food; and (2) direct ingestion of biosolids by children. Each Pathway considers risk to Highly Exposed Individuals (HEIs) rather than to the general population who seldom have appreciable exposure to biosolids or foods grown on biosolid-amended soils. Because present (1995) biosolids contain very low levels of PCBs in countries which have prohibited manufacture and use of these compounds, the estimated increase in lifetime cancer risk to HEIs from biosolids-borne PCBs applied to cropland or gardens was much less than 10 super(-4). Low biosolids PCBs and low probability of simultaneously meeting all the constraints of the HEI indicate that HEIs have less than 10 super(-7) increase in lifetime cancer risk from biosolids-borne PCBs; this provides even higher protection to the general population. We conclude that quantitative risk assessment for potentially toxic constituents in biosolids can be meaningfully conducted because research has provided transfer coefficients from biosolids and biosolid-amended soils to plants and animals needed to assess risk for many organic compounds.

ArticleTitle Cadmium uptake for Swiss chard grown on composted sewage sludge treated field plots: Plateau or time bomb?

Authors Chang, A.C.; Hyun, Hae-nam; Page, A.L.

Journal Journal of Environmental Quality, vol. 26, no. 1, pp. 11-19, Feb 1997

Abstract Two hypotheses have been proposed to describe the phytoavailability of potentially toxic metals in sewage sludge treated soils. The plateau theory argues that the metal adsorption capacity added with sludge will persist as long as the metals of concern persist in the soil and the metals would remain in chemical forms not readily available for plant uptake. Therefore, the metal concentrations of plant tissue will reach a plateau as sewage sludge mass loading increases and remain at this plateau after termination of sludge application. The sludge time bomb hypothesis postulates that a soil's metal adsorption capacity is augmented by soil organic matter added as sewage sludge. This capacity, however, will revert back to its original background level with time following termination of sewage sludge application as mineralization of organic matter releases metals into more soluble forms, thus a time bomb. We employed a set of experimental data obtained from a 10-yr field-based sewage sludge land application experiment to evaluate the hypotheses of the plateau and the time bomb. The evaluation involved analysis of Cd concentration of Swiss chard grown on soils that either received sewage sludge application continuously or no longer received sewage sludge application. The results indicate that necessary conditions for plateau and time bomb to take place may be found. But an actual plateau or time bomb was not evident from 10 yr of experimental data in which the sewage sludge application reached 2880 Mg ha super(-1).

ArticleTitle Assessing Phyto-availability of metals in biosolids-amended soils: root exudates and their effects on solubility of metals

Authors Chang, A.C; A.L. Page; B. Koo; D.E. Crowley; M.R. Matsumoto

Journal WEFTEC 99 Workshop 116 Recent Advances in Biosolids Research: Conditioning, Dewatering and Beneficial Use

Abstract

ArticleTitle Determination of acute Zn toxicity in pore water from soils previously treated with sewage sludge using bioluminescence assays.

Authors Chaudri Amar M(a); Knight Bruce P; Barbosa-Jefferson Vera L; Preston Sara; Paton Graeme I; Killham Ken; Coad Nicholas; Nicholson Fiona A; Chambers Brian J; McGrath Steve P

Journal Environmental Science & Technology 33 (11): p 1880-1885 June 1, 1999

Abstract The effects of increasing concentrations of Zn and Cu in soil pore water from soils of a long-term sewage sludge field experiment on microbial bioluminescence were investigated. Concentrations of total soluble Zn, free Zn²⁺, and soluble Cu increased sharply in soil pore water with increasing total soil metal concentrations above 140 mg of Zn kg⁻¹ or 100 mg of Cu kg⁻¹. Two luminescence bioassays were tested, based on two bacteria (*Escherichia coli* and *Pseudomonas fluorescens*) with the lux genes encoding bacterial luminescence inserted into them. The bioluminescence response of the two microorganisms declined as total soil Zn, soil pore water soluble Zn, and soil pore water free Zn²⁺ concentrations increased. The EC₂₅ values for *E. coli* and *P. fluorescens* were 1.3 ± 0.2 and 4.3 ± 0.5 mg L⁻¹ on a free Zn²⁺ basis, respectively. The EC₅₀ values were 2.5 ± 0.2 and 9.6 ± 0.9 mg of free Zn²⁺ L⁻¹, respectively. Copper had no significant effect on bioluminescence in the two assays, even at the largest soil pore water concentration of about 620 µg L⁻¹, corresponding to a total Cu concentration in bulk soil of about 350 mg kg⁻¹. Thus, the decline in bioluminescence of the two assays was ascribed to increasing soil pore water free Zn²⁺ and not soluble Cu.

ArticleTitle Metal tolerance of isolates of *Rhizobium leguminosarum* biovar *thiifolii* from soil contaminated by past applications of sewage sludge.

Authors Chaudri, A.M.; McGrath, S.P.; Giller, K.E.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. Feb 1992. v. 24 (2) p. 83-88.

Abstract We tested the tolerance to Cu, Ni, Cd and Zn of two isolates of *Rhizobium leguminosarum* biovar *trifolii* isolated from root nodules of clover plants grown in metal-contaminated sewage sludge treated plots (S-isolates) at Woburn Experimental Farm, and two isolates from root nodules of clover plants grown in uncontaminated control plots treated with farmyard manure (F-isolates). Survival of the isolates was compared in solutions containing different concentrations of Cu, Ni, Cd or Zn. The S-isolates from metal-contaminated soil were tolerant to larger concentrations of Cu, Ni, Cd and Zn compared to the F-isolates from uncontaminated control soil. The F-isolates were killed at concentrations of 0.002 microgram ml⁻¹ Cu, 0.2 microgram ml⁻¹ Cd 0.8 microgram ml⁻¹ Ni and 0.8 microgram ml⁻¹ Zn within 72 h, whilst the S-isolates survived, albeit in reduced numbers, at concentrations of 0.01 microgram ml⁻¹ Cu and 1.0 microgram ml⁻¹ Zn, but were killed by 1.0 microgram ml⁻¹ Ni and 0.8 microgram ml⁻¹ Cd within 72h. A particularly strong increase in tolerance to Zn was shown by the S-isolates compared to other metals at the same concentrations. Thus, the order of decreasing toxicity in solution to the two F-isolates was Cu > Cd > Zn = Ni, but for the two S-isolates it was Cu > Cd > Ni > Zn. The S-isolates have multiple metal tolerance that enables them to survive in metal-contaminated soil, but they have lost their ability to fix nitrogen with *Trifolium repens* L. The F-isolates can fix nitrogen, but these do not survive in metal-contaminated soil because they lack tolerance to these metals.

ArticleTitle Survival of the indigenous population of *Rhizobium leguminosarum* biovar *trifolii* in soil spiked with Cd, Zn, Cu and Ni salts.

Authors Chaudri, A.M.; McGrath, S.P.; Giller, K.E.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. July 1992. v. 24 (7) p. 625-632.

Abstract Solutions of Zn, Cd, Cu or Ni salts were added to a relatively uncontaminated soil, previously treated with farmyard manure (FYM), at six different concentrations for each metal. A further experiment compared the survival of the indigenous population of *Rhizobium leguminosarum* bv. *trifolii* in the same soil treated previously with FYM or metal-contaminated sewage sludge. No decline in rhizobial numbers occurred in either experiment after 2 months' exposure. After 18 months, the number of rhizobia in the control soils had declined by 90%. No rhizobia survived at Zn and Cd concentrations greater than or equal to 385 and greater than or equal to 7.1 micrograms g⁻¹ soil, respectively. At these Zn and Cd concentrations, which are ca 1.3 and 2.4 times the U.K. limits, respectively, there was no N₂-fixation. At the greatest Cu concentration of 225 micrograms g⁻¹ soil, which is 1.7 times the U.K. limit, there was a 99% decrease in rhizobial numbers compared to the control soil, but sufficient survived to give effective nodules on clover plants. Nickel had very little effect on the rhizobial population, even at the greatest concentration of 54 micrograms g⁻¹ soil, ca 75% of the U.K. limit. The order of decreasing toxicity to rhizobia in the soil, and hence the indirect effect on N₂-fixation, was Cd > Zn > Cu. The soil treated with metal-contaminated sewage sludge contained 230 rhizobial cells g⁻¹ soil after 18 months exposure. These could nodulate white clover, but were ineffective in N₂-fixation. Zinc and Cu concentrations in this soil were close to the U.K. limits, whereas Ni and Cd concentrations were half and 4 times the U.K. limits, respectively. Clover plants grown in soil spiked with Zn or Cd to give concentrations of greater than or equal to 385 and greater than or equal to 7.1 micrograms g⁻¹ soil, respectively, or in the sludge-treated soil, after 18 months exposure were chlorotic and stunted, and contained less N than the control plants grown in FYM-treated soil. These effects were not caused by phytotoxicity, because they were overcome by the addition of inorganic nitrogen fertilizer. Rather, they resulted from a direct toxic effect of these metals on the indigenous effective rhizobial population. It took 18 months exposure of the moist soil at 20 degrees C, in the absence of clover host plants, before the toxic effect became apparent.

ArticleTitle Enumeration of indigenous *Rhizobium leguminosarum* biovar *trifolii* in soils previously treated with metal-contaminated sewage sludge.

Authors Chaudri, A.M.; McGrath, S.P.; Giller, K.E.; Rietz, E.; Sauerbeck, D.R.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. Mar 1993. v. 25 (3) p. 301-309.

Abstract The effects of heavy metals from metal-contaminated sewage sludge on the indigenous population of *Rhizobium leguminosarum* biovar *trifolii* in the soils of two well controlled field experiments at Braunschweig in northeast Germany are reported. Both experiments were in the same field, but one was on an old arable soil and the other on an ex-woodland soil. The following treatments were applied to both experiments: inorganic fertilizer at 180 kg N ha⁻¹ yr⁻¹ (control soils); uncontaminated sludge at 100 m³ ha⁻¹ yr⁻¹ or 300 m³ ha⁻¹ yr⁻¹; or metal-contaminated sludge at the same two rates. In the ex-woodland experimental soil, rhizobial numbers decreased by an order of magnitude in plots treated with 100 m³ yr⁻¹ contaminated sludge compared to the control plots and plots receiving the same amount of uncontaminated sludge. The total Zn and Cd concentrations in these plots were close to the German limits, but were well below the U.K. and E.C. upper limits. Even with 300 m³ yr⁻¹ uncontaminated sludge rhizobial numbers decreased by several orders of magnitude compared to the control soils, in both field experiments: at both sites one of the four replicate plots had no rhizobia, whereas the other three plots had decreased numbers. Metal concentrations in these plots were well below the U.K. and E.C. upper limits, except Zn which was close to the German limit, and ranged from (mg kg⁻¹): Zn, 200-250; Cu, 46-62; Ni, 16-23 and Cd, 0.9-1.6. In plots receiving 300 m³ yr⁻¹ contaminated sludge, in both field experiments, rhizobial numbers were further decreased compared to plots receiving uncontaminated sludge at the same rate and were several orders of magnitude smaller than in the control plots. For example, in the old arable site, three out of four plots had no rhizobia, with one plot containing 20 cell g⁻¹ soil. In the ex-woodland site, two plots out of four had no rhizobia, whereas, the other two had < 4 and 9 cells g⁻¹ soil. Metal concentrations in these plots were above the U.K. and E.C. upper limits for Zn, but were still below the corresponding limits for Cd. Copper concentrations in one old arable plot and three ex-woodland plots were slightly above the U.K. limits for soils of pH 5-6. The German limits for Zn, Cu, and Cd, but not Ni, were considerably exceeded in these plots. The major factor influencing rhizobial numbers, in both field experiments, was not the soil pH, nor the organic carbon content, but rather the metal concentrations in the soil. The smaller N contents, chlorosis and stunting of clover plants grown in soils from plots containing no, or very few, rhizobia was not due to phytotoxicity, but was shown by the addition of nitrogen fertilizer to be due to lack of N₂-fixation. Our results indicate that although several metals were accumulated simultaneously in both field experiments there was a strong Zn effect on the numbers of rhizobia in these soils. Significant reductions in rhizobial numbers occurred even at metal concentrations well below the current U.K. and E.C. upper limits for all metals, but close to the much more strict German limits for Zn and Cd. These results are discussed in relation to the setting of safe limits for the long-term protection of soils.

ArticleTitle Comparative analysis of uptake rates of chemical elements by vegetables with use of sludge.

Authors Chipeva, S.; Marinova-Garvanska, S.

Journal Pochvoznanie, Agrokhimiya y Ekologiya vol. 33 (4): p.36-38, 1998

Abstract In a 3-year field experiment with cabbages, potatoes and lettuces at Kubratovo, Bulgaria, the effects of application of sewage sludge were investigated. Sludge from Sofia waste water treatment plant was applied at a rate of 40 t/ha annually before sowing. Analyses of plant N, P₂O₅, K₂O, Zn, Cu, Pb, Mn and Cd contents were made. The uptake of chemical elements by cabbages, potatoes and lettuces was similar in the different years. There were significant differences between the uptake of N, K₂O, Zn and Mn by the different vegetables. The highest uptake of N and K₂O, as well as of the heavy metals Zn and Mn, was by lettuces. For all the vegetables the highest uptakes were for K₂O, Zn and Mn. The uptake of Pb and Cd by all the vegetables was minimal and that by the lettuces was almost zero. 2 ref.

ArticleTitle Comparative biodegradation of a pharmaceutical under aerobic, semianaerobic and anaerobic conditions in an activated sludge system.

Authors Christensen, Karen P(a); Fackler, Paul H(a); Oleszkiewicz, Jan A; Sullivan, Daniel E

Journal Abstracts of Papers American Chemical Society 208 (1-2): p ENV 26 1994 Conference/Meeting: 208th National Meeting of the American Chemical Society Washington, D.C., USA, August 21-25, 1994

Abstract

ArticleTitle Soil profile distribution of heavy metals in a soil amended with sewage sludge for eight years.

Authors Colombo, L.; Mangione, D.; Bellicioni, S.; Figliolia, A.

Journal Agricoltura Mediterranea vol. 128 (4): p.273-283, 1998

Abstract A field experiment on a silty loam Cambisol in northern Italy was performed on a 3-course rotation (maize, sugarbeet and wheat) amended for 8 years with 7.5 or 15 t/ha of liquid, dewatered or composted sewage sludge. Cu, Zn and Ni were determined in soil layers at depths of 0-30, 30-60, 60-80 and 80-100 cm. Trace elements showed a moderate tendency to migrate below the amended layer. Heavy metal mobility was particularly evident when using DTPA-extracting solutions rather than the HNO₃ + HClO₄ mixture. 13 ref.

ArticleTitle Environmental risks associated with the presence of organic contaminants in various sewage sludges when used in agricultural and forest situations.

Authors Couillard, D.; Chouinard, P.; Mercier, G.

Journal Ministere des Forets du Quebec; Quebec; Canada, 1993, 109 pp.

Abstract A review is made of published literature on: contamination by sewage sludges; their behaviour with regard to the air, soil, and water; their effects on vegetation, soil organisms, and land and aquatic fauna; and the risks to human health. Most studies and experience to date indicate that the risks in using sewage sludges in agricultural and forest situations are low, both for the ecosystems and for human health. Practical recommendations are made for good practice: (1) rates of sludge application equivalent to 135 kg N/ha in 5 years and 200 kg N/ha in 10 years appear to be safe; (2) access to the sludge application site should be restricted for 12 months. Research priorities are identified, and a table is presented showing risk levels for different contents of organic compounds in the sludges when used in agriculture or forestry.

ArticleTitle Where's the limit? Changes in the microbiological properties of agricultural soils at low levels of metal contamination.

Authors Dahlin, S.; Witter, E.; Martensson, A.; Turner, A.; Baath, E.

Journal Soil-Biology-and-Biochemistry. 1997, 29: 9-10, 1405-1415; 38 ref.

Abstract A number of microbial properties previously shown to be sensitive to heavy metal toxicity were determined in soils from field experiments at Brunnby and Robacksdalen in Sweden. In the Brunnby soils, sewage sludge applications between 1966 and 1989 had increased the soil C content from 2.3 to 2.6% and reduced soil pH from 6.1 to 5.8. Concentrations of Cd, Cr, Cu, Pb and Zn in the soil had increased by up to 76%, but had not reached the current lower European Union limits for soils. Most of the measured microbial properties were affected by the sludge additions, although effects were generally moderate. Reductions were observed of between 15 and 80% in autotrophic and heterotrophic ARA potential, in numbers of rhizobia and in the biomass C:organic C ratio, and increases between 25 and 76% in the specific microbial respiration rate, and in the lag time and the specific microbial growth rate upon glucose addition. There were significant differences in the community structure determined by phospholipid fatty acid patterns between the high sludge treatment and the control and low sludge treatment, and in the bacterial community Cu tolerance between the high sludge treatment and the control. Basal respiration was not significantly affected by past sludge additions. At Robacksdalen, additions of metal salt solutions between 1979 and 1991 had increased soil concentrations of Cd, Cu and Pb by up to 23%, but soil concentrations were nevertheless below the background concentrations at Brunnby. In spite of the low metal concentrations, small, but statistically significant effects of metal addition on the specific respiration rate, lag time before the onset of microbial growth upon glucose addition and on potential autotrophic and heterotrophic ARA were found. The findings are discussed in relation to current legislation for soil protection.

ArticleTitle Study of the transfer of the medically used radionuclides in sewage systems

Authors Dalmasso, J.; Barci-Funel, G.; Barci, V.; Ardisson, G.

Journal Radiochimica Acta v 78 ., 1997, pp. 167-171

Abstract [Gamma]-emitting radionuclides were detected in sewage sludges from two sewage treatment plants at Nice, in South Eastern France, and Saint Laurent du Var, near Nice. The medically used radio-nuclides [^{99m}Tc], [²⁰¹Tl], [¹³¹I], [⁶⁷Ga] and [¹¹¹In] were measured daily during a sampling period of two months. A comparison of the calculated activity concentrations with the doses injected to the patients allowed us to determine the transfer time and the effective half-life of these different radionuclides in the two sewage systems.

ArticleTitle Sorption-desorption of 1,2,4-trichlorobenzene on soil: anionic surfactant and cationic polyelectrolyte effects.

Authors DiVincenzo, J.P.; Dentel, S.K.

Journal Journal-of-Environmental-Quality. 1996, 25: 6, 1193-1202; 27 ref.

Abstract The effect of sodium dodecyl sulfate (SDS) and/or a cationic polyelectrolyte (Percol 757) on the sorption-desorption of 1,2,4-trichlorobenzene (TCB) in soil (Typic Hapludult from Delaware, USA) was examined. Initial experiments varying sorbent mass resulted in non-constant partitioning and a non-linear isotherm; a model of incomplete colloidal separation by centrifugation could not explain the non-linearity. A proposed model quantified this isotherm behaviour with a BET isotherm equation related to the limiting sorption capacity of the organic matter phase, Q^{om}. Additions of SDS and/or polyelectrolyte led to significant changes in TCB sorption. The SDS decreased TCB sorption significantly, but only with SDS exceeding the critical micelle concentration (CMC). The CMC value itself varied with electrolyte and soil presence. Increasing the SDS concentration above the CMC caused TCB desorption from soil. The SDS also increased residual colloidal solids, but primarily below the CMC. Percol 757 slightly increased TCP sorption. With polymer added to soil containing SDS, TCB sorption was unaffected until charge equivalence was approached, whereupon sorption increased. This trend reversed when the SDS exceeded the sum of the polymer equivalence and the CMC. These results were explained in terms of polymer-surfactant interactions. Environmental implications of these results included the effects on transport of hydrophobic organics resulting from sludge disposal on land.

ArticleTitle Thermotolerant clostridia as an airborne pathogen indicator during land application of biosolids.

Authors Dowd, S.E.; Widmer, K.W.; Pillai, S.D.

Journal Journal-of-Environmental-Quality. 1997, 26: 1, 194-199; 29 ref.

Abstract A field study was conducted at a large commercial biosolid application site in Texas, USA, to determine if thermotolerant clostridia could be employed as a microbial indicator in determining the presence of such faecal contamination in aerosols. Even though the applied biosolids harboured as much as 107 most probable number faecal and total coliforms per gram wet weight, these traditional indicators were undetectable at locations having the greatest potential for aerosolization. Thermotolerant clostridia and bacteriophages, however, were detectable in 73% and 53% of the samples, respectively. Hydrogen sulfide producing bacteria as a group were detected in 93% of the samples. Even at sites directly in the vicinity of the biosolid application, thermotolerant clostridia were detected in 26% of the samples, as compared with the faecal and total coliforms which were detected in only 1 out of 15 (6.6%) samples. Since municipal sewage sludges usually undergo anaerobic digestion before land disposal, it would favour the selection of thermotolerant clostridia within these biosolids. Moreover, clostridia also could be ribotyped using the 16S-23S interspacer region length polymorphism to identify the origins or sources of aerosol contamination. Thermotolerant clostridia could thus serve as a reliable indicator to determine the presence of microbial pathogens and biosolid derived microbial populations in aerosols being generated from biosolid application programmes.

ArticleTitle Screening the environmental fate of organic contaminants in sewage sludge applied to agricultural soils: II. The potential for transfers to plants and grazing animals

Authors Duarte-Davidson, R; Jones, KC*

Journal Science of the Total Environment, Jun 1996, pp. 59-70, vol. 185, no. 1-3

Abstract This is the second of two papers which screen the environmental fate of sludge organic contaminants when applied to agricultural land. A simple screening model has been developed to assess the likelihood of organic contaminants accumulating into the food-chain following the application of sludge onto arable and pasture land. The purpose of this exercise is to highlight those compounds that have the potential to accumulate into plants and animal tissues using data on physico-chemical properties of the compounds of interest. Over 300 organic compounds or groups of compounds which have been identified as potential pollutants in sludge have been screened for their potential to transfer from sludge-amended soils to plants via retention by root surfaces, root uptake and translocation, foliar uptake and animal intake via soil and herbage ingestion. Various organic contaminants have been identified as having a high potential to transfer into the food-chain through plant and animal accumulation. Two priority lists have been produced to include (a) those compounds which are shown as being of sufficient or suspected importance, but for which further sludge concentration data and fate studies would be necessary to check on their status, and (b) those compounds which have been highlighted in the screening processes as having a high potential to accumulate up the food-chain. This screening approach can be adapted to other chemicals as information on new chemicals and their physico-chemical properties becomes available.

ArticleTitle Toxic chemical hazard due to agronomic use of sewage sludge. A review.

Authors Ducrot, C.; Meffre, C.

Journal Revue de Medecine Veterinaire. 1996, 147: 6, 439-444; 22 ref.

Abstract In this review, the agricultural use of sewage sludge is considered with reference to its toxic chemical content. It is concluded that there is a risk for consumers caused by the bioaccumulation of heavy metals and organic compounds (PCB, PCDD and PCDF) in plant, meat, animal fat and dairy products. Management practices to minimize human risk from the use of sewage are discussed.

ArticleTitle Pathogen reduction in sewage sludge by composting and other biological treatments: A review.

Authors Dumontet, S; Dinel, H; Baloda, S.B.

Journal Biological Agriculture & Horticulture; 16 (4). 1999. 409-430.

Abstract The agricultural utilization of sewage sludge imposes a high level of sanitation and stabilization of organic matter in order to maintain soil, water and air qualities and to effectively use such bioresidues as a soil amendment and as a source of nutrients for plants. Improper sanitation poses a serious threat to human and animal health. Stabilization and sanitation of sewage sludge have the advantage of coupling safe sewage sludge recycling in agriculture with its disposal, as many economic and studies in order to assess the environmental and health impacts of recycling sewage sludge through land application.

ArticleTitle Observations from a six month study on the effect of biodegradation processes in sediment on the toxicity potential of targeted chemicals

Authors Dutka, BJ; Liu, D; Jurkovic, A; McInnis, R; Lee, H-B; Onuska, F; Rao, SS

Journal ENVIR TOXICOL WATER QUAL, vol. 13, no. 4, pp. 313-322, Nov 1998

Abstract To illustrate the difficulties and problems involved in assessing the effect of biodegradation processes in sediments on the toxicity potential of targeted chemicals, a study was carried out to examine the relationship of aerobic and anaerobic biodegradation (on the ecotoxicity) of two priority organic chemicals (nonylphenol and aniline). The chemicals were spiked into heavily polluted Hamilton Harbour sediments and over a period of six months the changes in toxicity and genotoxicity (as assessed by 10 short-term bioassays) of the spiked sediments and their metabolites were monitored. The results indicated that under anaerobic conditions nonylphenol levels increased in concentration, while aniline quickly degraded under aerobic conditions and a little slower under anaerobic conditions. The data also revealed the inherent wide variability in toxicant distribution in homogenized sediment samples.

ArticleTitle Effects of sewage sludges contaminated with polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls on agricultural soils.

Authors Eljarrat, E.; Caixach, J.; Rivera, J.

Journal Environmental Science and Technology. 1997, 31: 10, 2765-2771; 28 ref.

Abstract The fate of sewage derived polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs) in soil is analysed. A general increase in pollutant concentration with the application rate was observed, especially in the case of the PCDDs. Levels of contamination in sludge-treated areas were compared with the limits proposed in Germany for agricultural and horticultural land uses. The results of the soil investigation showed that, in the case of an initial soil with low contamination, the final soil did not exceed the limit; but, in the case of an initial soil with considerable contamination, the final soil exceeded the limit, which restricts the cultivation of certain vegetables.

ArticleTitle Decline in PCDD and PCDF levels in sewage sludges from Catalonia (Spain)

Authors Eljarrat, Ethel; Caixach, Josep; Rivera, Josep

Journal Environmental Science & Technology, vol. 33, no. 15, pp. 2493-2498, 1999

Abstract Nineteen sewage sludges from rural and urban wastewater treatment plants (WWTPs) in Catalonia (Spain) were analyzed for PCDDs and PCDFs using HRGC-HRMS to determine the present levels of contamination. Total I-TEQ values for these samples ranged from 7 to 160 pg/g, with a mean value of 55 pg/g and a median value of 42 pg/g. Moreover, archived sewage sludge samples collected and stored between 1979 and 1987 from 15 WWTPs were analyzed to gain some insight into temporal trends and possible variations in source inputs. Total I-TEQ values for archived samples ranged from 29 to 8300 pg/g, with a mean value of 620 pg/g and a median value of 110 pg/g. Our findings show that contemporary sewage sludge PCDD/F concentrations have declined since the 1980s. In addition to the variations in PCDD and PCDF concentrations, there were also some changes in the isomeric patterns. These variations in levels and isomeric patterns could reflect changes in PCDD and PCDF sources to the environment over time.

ArticleTitle Bioavailability and DTPA-extractability of soil heavy metals from successive sewage sludge treated calcareous soil.

Authors Elsokkary, I. H.; Abdel Salam, A. A.

Journal Alexandria Journal of Agricultural Research vol. 43 (3): p.349-365, 1998, 36 ref.

Abstract Field experiments were conducted in Bangar El-Sokkar, Egypt to investigate bioavailability of Cd, Cu, Mn, Ni, Pb and Zn from calcareous soil receiving successive applications of sewage sludge. The field plots were distributed as a randomized complete block with five low sludge rates 0, 5, 10, 15 and 20 ton feddan-1 (1 feddan=0.42 ha) in the first winter growing season (Nov. 95) and sludge rates of 0, 10, 20, 30 and 40 ton feddan-1 in the second winter growing season (Nov. 96). Wheat and faba bean (*Vicia Faba*) were cultivated in this study. The results showed insignificant effects of sludge applications in the first winter growing season on both DTPA-extractable metals from soils, metals concentrations in plants and the aboveground biomass yields of faba bean and wheat. By the second winter growing season, the soil had received three successive application rates of the sludge: the initial application rates were increased to 0, 10, 20, 30 and 40 ton feddan-1 in the summer season of June 96 and the third application rates were the same as the second. Thus, cumulative amounts of 0, 25, 50, 75 and 100 ton sludge feddan-1 were added to the soil. The data of faba bean and wheat soils indicated significant increase in both DTPA- extractable metals, and concentrations of metals in leaves of the two plant species. The harvested aboveground biomass yields (straw and grains) were also significantly increased. The Cd and Zn concentrations in the leaves of the crops and also that extracted by DTPA from soils were significantly higher than those of Cu and Pb.

ArticleTitle Sewage sludge: resource or pollutant.

Authors Evans, G.; Rowland, P.; Walcott, J.; Mohammad-Asghar

Journal Proceedings of the 8th Australian Agronomy Conference, Toowoomba, Queensland, Australia, 30 January-2 February, 1996. 1996, 235-238; 10 ref.

Abstract Disposal of sewage sludge on agricultural land poses potential threats to ecological sustainability, including the possibility of long term contamination of agricultural soils and increased levels of cadmium in agricultural commodities and food above legislated safe levels. Under increasing pressure to find sustainable solutions, governments are faced with the dilemma of devising robust policies for the disposal of sewage sludge on rural lands that can adequately balance the potential pollution problem with the benefits of additional nutrients and organic matter.

ArticleTitle Technical support document for reduction of pathogens and vector attraction in sewage sludge.

Authors Farrell, Joseph B.

Journal Lexington, MA : Eastern Research Group, [1992] 1 v. (various pagings) : ill.

Abstract

ArticleTitle Effect of sewage sludge on the soil fertility on the growth of plants and productivity of maize (*Zea mays* L.)

Authors Favaretto N; Deschamps C; Daros E; Pissaia A

Journal ARQUIVOS DE BIOLOGIA E TECNOLOGIA , 1997 , v 40 , n4 , pp. 837-848

Abstract The sewage sludge organic fertilizer (32, 64 and 96 t ha⁻¹) with 90% of humidity) when compared with recommended mineral fertilizer and without fertilizer treatments on a field experiment with maize did not show differences on the grain productivity among dosages and therefore the sewage sludge can be used as a nutrient source with the smallest dosage since it did not show statistic difference in relation to mineral fertilizers. On the other hand, there was difference on growth of plants. The sewage sludge treatment increased the contents of P, Ca+Mg and V%. It decreased the potential acidity and not changed significantly the pH CaCl₂ and the contents of K, C organic and soil CTC pH 7.

ArticleTitle Behavior of Na super(131)I and meta (super(131)I) iodobenzylguanidine (MIBG) in municipal sewerage

Authors Fenner, FD; Martin, JE

Journal Health Physics, vol. 73, no. 2, pp. 333-339, Aug 1997

Abstract Behavior of super(131)I activity in primary sludge at the Ann Arbor, Michigan, Municipal Waste Water Treatment Plant was studied in relation to known radioiodine therapy events at the University of Michigan Hospital complex. The principal compounds administered are Na super(131)I, which has widespread use, and meta (super(131)I) iodobenzylguanidine (MIBG), which is a compound unique to the University of Michigan, although labeled antibodies and other forms are also used in therapy and research. The objectives of the study were to determine the environmental fate of such discharges and to determine radiation exposures to workers and the public when sludges are incinerated. Approximately 17% of the MIBG activity administered in a therapy was found in the primary sludge, whereas only 1.1% of the Na super(131)I was in sludge. When land applied, the short half life of super(131)I in the sludge presents few radiological health concerns; however, incineration, which is done in winter months, is assumed to release organically bound super(131)I to the atmosphere. Radiation doses due to incineration of sludge containing measured concentrations were calculated for a maximally exposed worker to be 1.7 mu Sv (0.17 mrem) of which 0.48 mu Sv (0.048 mrem) was due to a 2-d upset condition. For a more typically exposed worker, and a member of the public, the committed effective dose equivalents were 1.2 mu Sv (0.12 mrem) and 0.06 mu Sv (0.006 mrem), respectively, for a 22-wk incineration period with release of all radioiodine in the sludge. Transport time to the treatment plant for radioiodine was found to be much longer than that of normal sewage, possibly due to organic material in sewer lines that absorb iodine.

ArticleTitle Organotin compounds in municipal wastewater and sewage sludge: Contamination, fate in treatment process and ecotoxicological consequences

Authors Fent, K

Journal Science of the Total Environment, Jun 1996, pp. 151-159, vol. 185, no. 1-3

Abstract Organotin compounds find various applications in industry and agriculture, which may lead to contamination of municipal wastewater and sewage sludge. Here, an overview on the contamination of these media is given, and the behavior of organotins in the treatment process is described. In raw municipal wastewater of the city of Zuerich, Switzerland, mono- (MBT), di- (DBT) and tributyltin (TBT) were detected in the range of 140-560, 130-1030, and 60-220 ng/l, respectively. These compounds were primarily associated with suspended particulates, and transferred from wastewater to the sludge in the primary clarifier of the treatment plant. Both aerobic and anaerobic degradation were found to be insignificant. This has also been shown by a laboratory-scale sludge treatment system. After secondary and tertiary treatment, organotin concentrations were in the range of < 1-17 ng/l in the effluent of the plant. In digested sludge, concentrations of MBT, DBT and TBT were in the range of 0.3-0.8, 0.5-1.0 and 0.3-1.0 mg/kg (dry weight), respectively, in 1988-1990. A survey in 1995 in 25 treatment plants showed a similar contamination pattern with averages plus or minus S.E.M. of 0.5 plus or minus 0.2 mg/kg MBT, 1.5 plus or minus 0.5 mg/kg DBT and 1.1 plus or minus 0.4 mg/kg TBT. In seven sludges, phenyltins were found with averages of 0.1 plus or minus 0.04 mg/kg monophenyltin, 0.1 plus or minus 0.06 mg/kg diphenyltin and 0.5 plus or minus 0.2 mg/kg triphenyltin. The ecotoxicological consequences of organotin-polluted wastewater and sludge should be regarded concerning both the discharge of wastewaters into aquatic systems and the use of digested sludge as a soil amendment. Adverse effects on the most sensitive aquatic biota (gastropods) in receiving waters were shown at the concentrations found in plant effluents. The ecotoxicological implications of sludge derived organotin pollution on soils are not well understood, but bioaccumulation of these compounds in the terrestrial food web may occur.

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- ArticleTitle** Inactivation of viruses by digested sludge components
- Authors** Fenters, J.; Reed, J.; Lue-Hing, C.; Bertucci, J.
- Journal** Journal of the Water Pollution Control Federation 1979 , 51/4 (689-694)
- Abstract** A study was conducted to determine rates of inactivation of three enteroviruses seeded into anaerobically digested sludge supernatant. Ammonia, a major chemical component of sludge, also was evaluated at various concentrations for its effect on virus infectivity. Data indicated that virus inactivation rates varied to temperature over a range of 20degree to 35degreeC and that sludge supernatant had a greater impact on virus reduction than control Medium 199. In addition, the rate of Poliovirus 1 inactivation was increased in proportion to the concentration of ammonia over the range of 50 to 1,500 mg/l. Antibiotics added to sludge supernatants did not affect virus inactivation rates.
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- ArticleTitle** Fate of secondary alkane sulfonate surfactants during municipal wastewater treatment.
- Authors** Field, J.A.; Field, T.M.; Poiger, T.; Siegrist, H.; Giger, W.
- Journal** Water-Research-Oxford. 1995, 29: 5, 1301-1307; 21 ref.
- Abstract** A field study was conducted to determine the mass flow of secondary alkane sulfonate (SAS) surfactants in a municipal wastewater treatment plant. The concn of SAS in samples of sewage (raw sewage, primary and secondary effluent) was determined using solid-phase extraction with C18 disks and injection port derivatization with gas chromatography/mass selective detection (GC/MS). The concn of SAS in raw and anaerobically-digested sludge was determined by ion-pair/supercritical fluid extraction and injection-port derivatization GC/MS. The removal of SAS from the waste stream is efficient (99.7%) with _ 16% (w/w) transferred to sludge. Given current Swiss sludge disposal regulations, a maximum of _ 350 m-2SAS are applied every three years to a given section of agricultural soil. Of the total SAS mass flow entering the treatment plant, an average of 0.3% (w/w) is discharged to the adjacent receiving water stream.
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- ArticleTitle** Soil microbial biomass and microbial activity in soils treated with heavy metal contaminated sewage sludge.
- Authors** Fliessbach, A.; Martens, R.; Reber, H.H.
- Journal** Soil-biol-biochem. Exeter : Elsevier Science Ltd. Sept 1994. v. 26 (9) p. 1201-1205.
- Abstract** Soil microbial biomass carbon (Cmic) and respiration were measured in soils from two long-term field experiments with recent sewage sludge applications. A moderately contaminated sludge was applied as received from the sewage treatment plant and after additional metal contamination. Generally, the low metal sludge had beneficial effects on Cmic and on the soil microbial activity. Higher heavy metal contamination of soils resulted in a substantial decrease in Cmic. The ratio Cmic/Corg even decreased when low metal sludge was applied. Soil respiration and especially the respiration per unit biomass (qCO2) increased with increasing amounts of heavy metals. Concomitantly the contribution of fungi to soil respiration increased. Judging from these results the qCO2 appears to be a sensitive indicator of effects that are resulting from the effects of heavy metals on the soil microflora.

ArticleTitle Ingestion of sludge applied organic chemicals by animals

Authors Fries, GF

Journal Science of the Total Environment, Jun 1996, pp. 93-108, vol. 185, no. 1-3

Abstract Intake of sludge-borne chemicals is related to the crop and animal management systems, the species and physiological status of animals, and the properties of the chemicals. The greatest intake occurs when sludge is applied to established crops and animals have immediate access. Intake is reduced when access is delayed to allow losses by weathering and dilution by plant growth, or when sludge is incorporated into soil because vapour transport from soil to plants and lower concentrations at the surface reduce intake via soil ingestion. Animals that consume forage are the most subject to contaminant exposure, which is maximized when pasture is the major component of the diet because soil ingestion is an additional exposure pathway. Of the many organic contaminants in sludges, only lipophilic halogenated hydrocarbons accumulate in animal tissues and products. Compounds like phthalate esters, PAHs, acid phenolics, nitrosamines, volatile aromatics, and aromatic surfactants are metabolized and do not accumulate. Among halogenated hydrocarbons, compounds with low degrees of halogenation are metabolized and do not accumulate, but higher degrees of halogenation block metabolism, and concentrations in milk and tissue fat may be several-fold greater than in the diets.

ArticleTitle Urban sludge reused for agricultural purposes: parasitic contamination and development of a model for health risk assessment. > OT: Valorisation des boues de stations d'epuration en vue de l'amelioration des sols destines a l'agriculture: contamination parasitaire et modelisation en vue de la gestion du risque sanitaire.

Authors Gaspard, P.; Ambolet, Y.; Schwartzbrod, J.

Journal Bulletin de l'Academie Nationale de Medecine. 1997, 181: 1, 43-57; 14 ref.

Abstract Helminth eggs (especially *Ascaris* and *Taenia*) and protozoan cysts (*Cryptosporidium* and *Giardia*) present in urban sludge constitute a health risk when the sludge is used to enrich agricultural soil. Parameters affecting *Ascaris suum* egg survival in soils, such as humidity, temperature and soil texture, were determined and studied in various types of soil. Survival experiments were carried out in clayey soil, silty-loam and sandy soil with a range of humidity levels (from field capacity to wilting point) and temperature variation (4, 19 and 30°C). The results showed that temperature was an important factor for egg survival in all types of soils, with survival times >2 years at 4°C. No difference in survival rate was observed at 19 and 30°C. Humidity was the second most important parameter, with good egg viability maintained at wilting point. Soil depth was also an important factor, with deeper soils protecting the eggs from desiccation. A model combining the experimental data with continental climatic conditions indicated egg survival rates of 0.35% in surface soil and 10.6% in deeper soil after 1 year. The data could be used to establish regulations for the use of urban sludge for agricultural purpose.

ArticleTitle Sludge hygienization: helminth eggs (*Ascaris ova*) destruction by lime treatment.

Authors Gaspard, P.G.; Wiart, J.; Schwartzbrod, J.

Journal Recent Research Developments in Microbiology. 1997, 1: 77-83; 11 ref.

Abstract It was found that pH (NaOH, pH >13) greatly altered the viability of *Ascaris ova*, within 30 to 60 days. The effects of lime concentration and pH were studied simultaneously: the lime concentration had to be sufficiently high in order to reach the desired pH level, but also in order to maintain the pH throughout the duration of storage. A pH of >12.0 was required to ensure removal of *Ascaris ova* within 3 months; 6 months was required at pH 11.0. For pHs of <11.0, the lime activity was reduced and a period of >6 months was required.

ArticleTitle Parasitological contamination of urban sludge used for agricultural purposes

Authors Gaspard, P; Wiart, J; Schwartzbrod, J

Journal Waste Management & Research, vol. 15, no. 4, pp. 429-436, Aug 1997

Abstract Sludge re-use in agriculture has increased in many countries, but this practice must be associated with a knowledge of the pathogens present in these sludges. The aim of this study was to determine the parasitic contamination of helminths found in urban sludges. Parasitological analysis was then performed on 99 samples collected by the waste recycling mission for agricultural purposes: urban sludges (89), lagoon sediments (3) and composts (7). The results of 89 urban sludge analyses expressed per 100 g of dry matter showed a high proportion (47%) of samples presenting concentrations lower than 60 eggs. Thirty-eight per cent of the samples were with higher concentrations ranging from 60 to 240 eggs; only 15% of the analysis results indicated concentrations higher than 240 eggs with a maximum of 898 eggs. In lagooning sediments, the concentration observed ranged from 56 to 569 eggs and the analysis of compost samples yielded average concentration of 40.8 eggs. When the whole study is taken into account, Nematode eggs (*Toxocara*, *Ascaris*, *Capillaria*, *Trichuris*, *Ascaridia*, *Enterobius*) are mostly represented with 93.2%, whereas Cestode eggs (*Tenia*, *Hymenolopis*) are only detected in a proportion of 6.8%. The study of the lime treatment impact on 10 treatment plants showed a decrease in helminth eggs concentration in seven samples and no difference for the three others. For the egg viability, sludges from all types of treatment (mesophilic anaerobic and aerobic digestion, composting, liming) contained viable eggs in concentration higher than or equal to 10 eggs per 100 g of dry matter.

ArticleTitle Parasitological contamination of urban sludge used for agricultural purposes.

Authors Gaspard, Philippe(a); Wiart, Jacques; Schwartzbrod, Janine(a)

Journal Waste Management & Research 15 (4); p 429-436 1997

Abstract Sludge re-use in agriculture has increased in many countries, but this practice must be associated with a knowledge of the pathogens present in these sludges. The aim of this study was to determine the parasitic contamination of helminths found in urban sludges. Parasitological analysis was then performed on 99 samples collected by the waste recycling mission for agricultural purposes: urban sludges (89), lagoon sediments (3) and composts (7). The results of 89 urban sludge analyses expressed per 100 g of dry matter showed a high proportion (47%) of samples presenting concentrations lower than 60 eggs. Thirty-eight per cent of the samples were with higher concentrations ranging from 60 to 240 eggs; only 15% of the analysis results indicated concentrations higher than 240 eggs with a maximum of 898 eggs. In lagooning sediments, the concentration observed ranged from 56 to 569 eggs and the analysis of compost samples yielded average concentration of 40.8 eggs. When the whole study is taken into account, Nematode eggs (*Toxocara*, *Ascaris*, *Capillaria*, *Trichuris*, *Ascaridia*, *Enterobius*) are mostly represented with 93.2%, whereas Cestode eggs (*Tenia*, *Hymenolopis*) are only detected in a proportion of 6.8%. The study of the lime treatment impact on 10 treatment plants showed a decrease in helminth eggs concentration in seven samples and no difference for the three others. For the egg viability, sludges from all types of treatment (mesophilic anaerobic and aerobic digestion, composting, liming) contained viable eggs in concentration higher than or equal to 10 eggs per 100 g of dry matter.

ArticleTitle Canadian Environmental Quality Guidelines for mercury

Authors Gaudet, C; Lingard, S; Cureton, P; Keenleyside, K; Smith, S; Raju, G

Journal THIRD INTERNATIONAL CONFERENCE ON MERCURY AS A GLOBAL POLLUTANT., 1995, pp. 1149-1159, Water, Air, & Soil Pollution, vol. 80, no. 1-4

Abstract CCME Canadian Environmental Quality Guidelines for mercury have been recommended or are under development for soil, water and sediments. These guidelines provide nationally consistent benchmarks for environmental quality across Canada and are intended as decision support tools in protecting and sustaining aquatic and terrestrial ecosystems in Canada and the beneficial uses they support. A Canadian water quality guideline for protection of aquatic life was recommended in 1987 as 0.1 $\mu\text{g times L super}(-1)$. Currently, mercury guidelines for soils and sediments are under development. Preliminary calculations indicate that interim marine and freshwater sediment guidelines for the protection of aquatic life will both be 0.14 $\text{mg times kg super}(-1)$; and that soil quality guidelines will be 2.0 $\text{mg times kg super}(-1)$ (agricultural and residential land uses), and 30.0 $\text{mg times kg super}(-1)$ (commercial and industrial land uses). Final the Canadian Council of Ministers of the Environment

ArticleTitle Effect of sewage sludge and ammonium nitrate on wheat yield and soil profile inorganic nitrogen accumulation.

Authors Gavi Francisco; Raun William R(a); Basta Nicholas T; Johnson Gordon V

Journal Journal of Plant Nutrition 20 (2-3): p 203-218 1997

Abstract The beneficial effect of sewage sludge in crop production has been demonstrated, but there is concern regarding its contribution to nitrate (NO_3) leaching. The objectives of this study were to compare nitrogen (N) rates of sewage sludge and ammonium nitrate (NH_4NO_3) on soil profile (0-180 cm), inorganic N (ammonium nitrate ($\text{NH}_4\text{-N}$) and nitrate nitrogen ($\text{NO}_3\text{-N}$)) accumulation, yield, and N uptake in winter wheat (*Triticum aestivum* L.). One field experiment was established in 1993 that evaluated six N rates (0 to 540 $\text{kg cntdot ha}^{-1} \text{ cntdot yr}^{-1}$) as dry anaerobically digested sewage sludge and ammonium nitrate. Lime application in 1993 (4.48 Mg ha^{-1}) with 540 $\text{kg N ha}^{-1} \text{ cntdot yr}^{-1}$ was also evaluated. A laboratory incubation study was included to simulate N mineralization from sewage sludge applied at rates of 45, 180, and 540 $\text{kg N ha}^{-1} \text{ cntdot yr}^{-1}$. Treatments did not affect surface soil (0-30 cm) pH, organic carbon (C), and total N following the first (1994) and second (1995) harvest. Soil profile inorganic N accumulation increased when $\geq 270 \text{ kg N ha}^{-1}$ was applied as ammonium nitrate. Less soil profile inorganic N accumulation was detected when lime was applied. In general, wheat yields and N uptake increased linearly with applied N as sewage sludge, while wheat yields and N uptake peaked at 270 kg N ha^{-1} when N was applied as ammonium nitrate. Lime did not affect yields or N uptake. Fertilizer N immobilization was expected to be high at this site where wheat was produced for the first time in over 10 years (previously in native bermudagrass). Estimated N use efficiency using sewage sludge in grain production was 20% (average of two harvests) compared to ammonium nitrate. Estimated plant N recovery was 17% for sewage sludge and 27% for ammonium nitrate.

ArticleTitle Use of sewage sludge - nitrogen availability and heavy metal uptake into rape.

Authors Gerzabek, M. H.; Lombi, E.; Herger, P.

Journal Bodenkultur vol. 49 (2): p.85-96, 1998, 19 ref.

Abstract A three-year field experiment with large pots in Austria evaluated the effects of sewage sludge (sterilised by gamma -irradiation or not sterilised) on rape growth, heavy metal- and N-uptake, using the ^{15}N -dilution technique. Mobile fractions of Cd, Cu and Zn increased significantly in the substrate due to sewage sludge treatments. However, heavy metal transfer into rape plants did not respond clearly. Rape growth was enhanced in the first and third years due to sewage sludge applications. The average N-utilisation by rape from sewage sludge in a three-year period decreased from 7.4% (first year), 1.8% (second year) to 1.1.% (third year), resulting in an overall utilisation of 10.3% of sewage sludge-N by rape plants. Irradiation of sewage sludge did not result in any significant effect on the investigated parameters.

ArticleTitle Rhizobium meliloti is less sensitive to heavy-metal contamination in soil than R. leguminosarum bv. trifolii or R. Loti.

Authors Giller, K.E.; Nussbaum, R.; Ghaudri, A.M.; McGrath, S.P.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. Feb 1993. v. 25 (2) p. 273-278.

Abstract A gradient of soils with increasing metal contamination was constructed by mixing uncontaminated farmyard manure-treated (FYM) and contaminated, sewage sludge-treated (S) soils from the Woburn Experimental Farm, and separate samples of these soils were inoculated with strains of Rhizobium leguminosarum bv. trifolii, R. meliloti and R. loti. The survival of rhizobia in these soils was monitored using most-probable number (MPN) plant infection tests. After 51 days incubation numbers of R. meliloti were similar in all of the soils irrespective of the heavy metal content, whilst the numbers of R. leguminosarum bv. trifolii and R. loti were reduced in soils containing more than 2/3 sludge-treated soil. The numbers of R. leguminosarum bv. trifolii were monitored in the same gradient of soils over a 171 day period and differences in survival between the soils were only apparent from 27 days in soil mixtures containing more than 5/6 sludge-treated soil. After 171 days the number of cells surviving had decreased even in the soil mixture containing 1/6 sludge-treated soil when compared with the uncontaminated FYM-treated soil. The populations of indigenous R. leguminosarum bv. trifolii were also monitored in the soil of the FYM-treated and S-treated plots in the field. Numbers of rhizobia remained at around 4×10^4 cells g soil⁻¹ in the FYM-treated soil over 3 yr after clover was removed, but gradually declined in the S-treated soil to 1×10^3 cells g soil⁻¹.

ArticleTitle Predicting plant available nitrogen in land-applied biosolids

Authors Gilmour, John T.; Skinner, Vaughn

Journal Journal of Environmental Quality v 28 n 4 1999. p 1122-1126, 11 Refs.

Abstract The rate at which biosolids (municipal sewage sludge) may be applied to land is dependent on factors including concentrations of metals, pathogens, toxic organic compounds, and nutrients. Where other properties are not limiting, land application rates are often based on matching crop N needs with the plant available N (PAN). The objectives of this study were to quantify biosolids PAN under field conditions and to propose methods including computer simulation to estimate biosolids PAN in a land application program. Six biosolids were evaluated over a 2-yr period. Laboratory incubations were used to obtain decomposition kinetics. Field studies provided a relationship between inorganic fertilizer N rate and sorghum sudangrass left bracket Sorghum bicolor (L.) Moench right bracket tissue N concentration, which was used to determine biosolids PAN in a Captina silt loam soil (fine-silty, siliceous, mesic Typic Fragiudult). Biosolids PAN released during the field experiment was linearly related to biosolids C/N ratio, organic N, or total N. Computer model predictions of PAN in the field were also linearly related to field estimates of biosolids PAN. Decay series (first and second year N mineralization percentages) obtained using the computer model, average biosolids decomposition kinetics, and average application site weather were very similar to decay series obtained using the computer model, actual weather, and kinetic data. Either decay series and routine analytical data for biosolids are proposed to estimate PAN for a given situation. Use of the computer model and weather data makes the approach site-specific, while analytical data for a specific biosolids makes the approach biosolids-specific.

ArticleTitle Environmental fate and effects of DEEDMAC: a new rapidly biodegradable cationic surfactant for use in fabric softeners.

Authors Giolando, S.T.; Rapaport, R.A.; Larson, R.J.; Federle, T.W.; Stalmans, M.; Masscheleyn, P.

Journal Chemosphere. 1995, 30: 6, 1067-1083; 32 ref.

Abstract The biodegradation of a new fabric softening cationic surfactant, the di-(tallow fatty acid) ester of di-2-hydroxyethyl dimethyl ammonium chloride (DEEDMAC) is described. DEEDMAC differs structurally from DTDMAC (ditallow dimethyl ammonium chloride or DTDMAC, a major cationic surfactant in use for >30yr) by the inclusion of two weak ester linkages which allow it to be rapidly and completely biodegraded under various conditions: standard laboratory screening tests, raw sewage, activated sludge, anaerobic digester sludge, sludge amended soil, and river waters. Over 99% of the DEEDMAC was removed during sewage treatment. Based upon estimates of max. predicted environmental concn of DEEDMAC, acute and chronic toxicity testing of fish, invertebrates and algae, predicted aquatic safety factors of 272 to >1000. Predicted steady state terrestrial safety factors were >1000, as based on EC50 values to earthworms and plants >50 mg/kg. DEEDMAC had an ecotoxicity profile similar to commonly used anionic and nonionic surfactants, and was therefore considered to be environmentally safe at its intended max. usage volumes.

ArticleTitle Mercury in soils and crops from fields receiving high cumulative sewage sludge applications: Validation of U.S. EPA's risk assessment for human ingestion

Authors Granato, TC; Pietz, RI; Gswind, J; Lue-Hing, C

Journal THIRD INTERNATIONAL CONFERENCE ON MERCURY AS A GLOBAL POLLUTANT., 1995, pp. 1119-1127, Water, Air, & Soil Pollution, vol. 80, no. 1-4

Abstract The Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) has owned and operated a 6320 ha Dedicated Beneficial Sludge Utilization Site in Fulton County, Illinois since 1971. The site consists of calcareous strip mine spoil intermingled with placed land. Sewage sludge from Chicago is barged to the site, located approximately 185 miles southwest of the city, and utilized to reclaim the strip mined soils and to fertilize the corn and wheat crops grown on them. Fields have received as much as 1317 dry Mg ha super(-1) of sewage sludge since 1971. Sludge Hg concentrations have ranged from 1.1 to 8.5 mg Hg kg super(-1) with mean concentration of 3.31 mg Hg kg super(-1), and maximum cumulative Hg loading rates are approximately 4 kg ha super(-1). Sludge applications have significantly increased extractable soil Hg concentrations, and regression analysis indicates that from 80 to 100% of the Hg applied to soils in sewage sludge since 1971 still resides in the top 15 cm of soil. Since 1985 the MWRDGC has been monitoring Hg concentration in corn leaf and grain, wheat grain and soils at the Fulton County site. Monitoring data indicate that 98.8% of the corn grain samples, 93.0% of the wheat samples and 50.7% of the corn leaf samples collected from 1985 through 1992 had Hg concentrations below detectable limits (<25 µg kg super(-1)). Cumulative Hg loading rates are utilized along with crop tissue concentrations to compute crop uptake response slopes (UC) for Hg into plant tissues at the Fulton County site. The UC for corn and wheat grain was zero and for corn leaf was -0.0014 (mg Hg/kg tissue)/(kg Hg/ha soil), which indicate that sewage sludge additions did not increase plant tissue Hg concentrations at the Fulton County site. The negative UC obtained for corn leaf may actually indicate that sewage sludge applications decreased Hg uptake from mined soils possibly due to organic carbon and sulfides in the anaerobically digested sludge binding native Hg. The United States Environmental Protection Agency (U. S. EPA) has recently promulgated their 40 CFR Part 503 regulation for sewage sludge use and disposal. The rule sets risk based limits on ten metals, including Hg, in sludges that are land applied. Exposure pathways involving plant uptake of Hg are briefly discussed and it is shown that the UC used in U.S. EPA's risk assessment models for these pathways overpredict uptake of Hg by crops when compared with the UC derived from the MWRDGC's monitoring data at Fulton County.

ArticleTitle Mobilization of PAH and PCB from contaminated soil using a digestive tract model

Authors Hack, A; Selenka, F

Journal PROCEEDINGS OF THE FIFTH EUROPEAN MEETING OF ENVIRONMENTAL HYGIENE., Nov 1996, pp. 199-210, Toxicology Letters, vol. 88, no. 1-3

Abstract Environmental contaminants are mainly incorporated by ingestion. In general only those contaminants mobilized by the digestive juices are available for absorption in the digestive tract, while pollutants still fixed to indigestible particles leave the body without any effect. To evaluate the different health risks arising from the ingestion of individual types of polluted soil or other materials, we developed an in vitro test system which simulates the transition of pollutants from contaminated materials into digestive juices by means of a standardized artificial gastro-intestinal model. The test system simulates the influence of the acidic environment of the stomach (gastric model) followed by the neutral or slightly alkaline environment of the small intestine (gastro-intestinal model). Investigations on small amounts of polluted soil, sewage sludge, asphalt, metal scrap and blast sand showed that the mobilization of polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) by artificial gastric juice reaches 3% up to 22% of the pollutant concentration introduced into the test system. Elutions of the contaminated materials under gastric and subsequently under intestinal conditions with bile concentrations of 3 g/l resulted in PAH- and PCB-mobilizations in the range of 5% up to 40%. The degree of mobilization depends considerably on supplementary food material added to the test system. Lyophilized milk increased the fraction of mobilized PAH and PCB to 40%-85%. Application of the test system on 22 different contaminated soils showed that the mobilization of PAH under gastro-intestinal conditions with the addition of lyophilized milk ranged from 7% up to 95%, and the mobilization of PCB ranged from 32% up to 83%. This indicates that the test system can be a useful tool for evaluating the individual health risks arising from polluted soil or other materials.

ArticleTitle A review of the interaction of surfactants with organic contaminants in soil.

Authors Haigh, S.D.; Jones, K. (ed.); Alcock, R.

Journal Organic contaminants in sewage sludges. Proceedings of International Symposium, Lancaster University, UK, 16-17 May 1995. Science-of-the-Total-Environment. 1996, 185: 1-3, 161-170; 53 ref.

Abstract Surfactants present in sewage sludge-amended soil can interact with other xenobiotics in soil, such as chlorinated organics and polycyclic aromatic hydrocarbons. The ability of surfactants to solubilize relatively insoluble xenobiotics has been exploited in many industries and in the decontamination of groundwater aquifers, in soil clean-up operations and to remediate land polluted with oils and hydrocarbons. Some surfactants, even at very low concn, have also been shown to enhance the biodegradation of certain xenobiotics in soil. Surfactant-pollutant interactions in soil are very complex and depend heavily on a range of parameters including surfactant concn in soil-water compared with critical micelle concn (CMC), the adsorption characteristics of the surfactant and pollutant, solubility of the pollutant and the soil type. The most important parameter in terms of the ability of a surfactant to mobilize hydrophobic xenobiotics in contaminated soil is the surfactant CMC. ! In environments, such as soils and sediments, adsorption of surfactants to surfaces results in much higher total surfactant concn being necessary to achieve micellization in pore water than would be necessary in clean water systems. Therefore, much higher concn of surfactant are required than might be expected to cause significant changes in xenobiotic behaviour. Such high concn are not typical of those found in sludge-amended soil.

ArticleTitle Biodegradation of the anionic surfactant dialkyl sulphosuccinate.

Authors Hales, S.G.

Journal Environmental Toxicology and Chemistry. 1993, 12: 10, 1821-1828; 7 ref.

Abstract A range of Organisation for Economic Cooperation and Development (OECD) guideline test systems was used to determine the extent and possible mechanisms of biodegradation of dialkyl sulphosuccinate (DACC, C6/D8). Primary biodegradation of DASS was virtually complete in OECD guideline tests and in simulations of activated sludge sewage treatment systems under optimal and adverse conditions, in river water die-away tests and in anaerobic digesters. Ultimate biodegradation increased from ~50% in ready tests to 94% in more powerful inherent tests. [¹⁴C]DASS was used to determine the fate of the surfactant in activated sludge and in surface waters. Mechanistic studies were performed to ascertain the biodegradative pathway of [¹⁴C]DASS. A putative degradation pathway for DASS was proposed.

ArticleTitle Physiological effects of the detergent linear alkylbenzene sulphonate on blue mussel larvae (*Mytilus edulis*) in laboratory and mesocosm experiments

Authors Hansen, B.; Fotel, F.L.; Jensen, N.J.; Wittrup, L

Journal Marine Biology, vol. 128, no. 4, pp. 627-637, Jun 1997

Abstract A series of laboratory (short-term exposure in small beakers) studies and a 19 d mesocosm (6 m super(3) polyethylene bags filled with fjord water) study were conducted on blue mussel, *Mytilus edulis*, larvae and plantigrades exposed to a concentration gradient of the detergent linear alkylbenzene sulphonate (LAS, 0 to 39 mg l⁻¹). LAS is increasingly found in nearshore environments receiving wastewater from urban treatment plants. The aims were to observe physiological effects on swimming, grazing and growth in the laboratory and effects on settling and population development at in situ conditions (in field mesocosms) in order to evaluate the damages on ciliated meroplankton caused by LAS. In the laboratory the larvae showed a 50% mortality at 3.8 mg LAS l⁻¹ after 96 h exposure whether or not food was provided. Additionally the swimming behaviour was affected at 0.8 mg LAS l⁻¹ (i.e. a more compact swimming track, a smaller diameter of the swimming tracks, and reduced swimming speed). The larval particle grazing was reduced 50% at 1.4 mg LAS l⁻¹. The specific growth rate of the larvae was reduced to half at 0.82 mg LAS l⁻¹ over 9 d. During the mesocosm experiment, the larval population showed a dramatic decrease in abundance within 2 d at concentrations as low as 0.08 mg LAS l⁻¹, both due to a significantly increased mortality, but also due to settling. The settling success was reduced at the same LAS concentration as that at which mortality was observed to increase significantly. In addition to reduced settling rate, the larvae showed delayed metamorphosis and reduced shell growth as a response to LAS. Our hypothesis that the larval ciliary apparatus, crucial for normal swimming, orientation, and settling behaviours and for particle uptake, was damaged due to LAS exposure is supported by our results. This is confirmed by the physiological data (grazing, growth) and in the direct video-based observations of larval performance (swimming) and provides a reasonable explanation for what was observed in the bags (abundance, settling, mortality). These physiological effects on blue mussel larvae /plantigrades occurred at LAS concentrations reported to occur in estuarine waters.

ArticleTitle Bioaccumulation and metabolic fate of sewage sludge derived organic xenobiotics in plants

Authors Harms, H.H.

Journal Science of the Total Environment, Jun 1996, pp. 83-92, vol. 185, no. 1-3

Abstract Sewage sludges will always contain a very complex mixture of organic contaminants. Therefore, information is needed to provide data on the persistence of these sludge derived organics in soils and their uptake by food crops. The results of this study demonstrate that all compounds, even non-polar ones, are assimilated by intact plants and different in vitro systems. Uptake depended on the plant species and on the physico-chemical properties of the chemicals. The main metabolites being formed are polar conjugates with carbohydrates and amino acids. Polycyclic aromatic hydrocarbons (PAHs) are partly converted to oxygenated derivatives which are known to be even more toxic. Depending on the plant species, and especially in monocots, large amounts of the chemicals and/or their metabolites, are frequently incorporated into non-extractable residues. The association, and type of binding to cell wall components, enable conclusions to be made about the bioavailability of these bound residues.

ArticleTitle Land application of sewage sludges: an appraisal of the US regulations.

Authors Harrison, E.Z.; McBride, M.B.; Bouldin, D.R.

Journal International Journal of Environment and Pollution. 1999, 11: 1, 1-36; 4 pp. of ref.

Abstract Current US federal regulations governing the land application of sewage sludges do not appear adequately protective of human health, agricultural productivity or ecological health. US standards are far less protective than those of many European countries and Canadian provinces. This is due to both policy choices such as a 'do no harm' philosophy applied in some northern European countries and also to many gaps and non-conservative assumptions in the risk assessment performed by the USA's Environmental Protection Agency. The potential for widespread use of sludges on agricultural and residential land, the persistence of many of the pollutants, which may remain in soils for a very long time, and the difficulty of remediation support a cautious approach. Soil, water and crop characteristics in New York State and other areas of the northeastern US raise particular concerns. The paper does not suggest a prohibition of land application but, rather, significantly more restrictive use. Limiting cumulative additions of pollutants to prevent soils from exceeding recommended maximum contaminant levels can be achieved by application of clean sludges or by application of lesser amounts of less high quality sludges. Further investigation is needed to assess risks to ground and surface water and to establish standards for additional contaminants.

ArticleTitle Use of municipal waste products in energy forestry: Highlights from 15 years of experience.

Authors Hasselgren Kenth(a)

Journal Biomass and Bioenergy 15 (1): p 71-74 1998

Abstract Pre-treated wastewater, sewage sludge and methanogenic landfill leachate were applied to short rotation energy forestry, i.e. Salix (willow) plantations. The nutrient content in wastewater was well balanced with the nutrient uptake in Salix stems. With sludge and leachate used as the main fertilizer resource, potassium and phosphorus fertilizers, respectively, must be added for sustainable biomass production. In most cases the growth was increased after application of the waste products. Production rates at same or higher levels as conventionally-fertilized willow plantations were recorded. Water is pointed out as the single most important growth factor. Waste management according to presented concepts could offer good treatment performance without adverse effects on soil, groundwater or vegetation. During the course of the field tests full-scale applications have been established.

ArticleTitle A Preliminary evaluation of some soil and plant parameters that influence root uptake of arsenic, cadmium, copper and zinc

Authors Hattemer-Frey, H.A.; G.R. Krieger; V. Lau

Journal

Abstract

ArticleTitle Environmental fate of the primary degradation products of alkylphenol ethoxylate surfactants in recycled paper sludge

Authors Hawrelak, M; Bennett, E; Metcalfe, C

Journal Chemosphere, vol. 39, no. 5, pp. 745-752, 1999

Abstract Alkylphenol ethoxylates (APEOs) are a group of non-ionic surfactants that are degraded microbially into more lipophilic degradation products with estrogenic potential, including nonylphenol monoethoxylate (NP1EO), nonylphenol diethoxylate (NP2EO), octylphenol (4-tOP) and nonylphenol (4-NP). Nonylphenol ethoxylates are used in paper recycling plants for de-inking paper and have the potential to be released into the environment through spreading of wastewater treatment sludge for soil amendment. Three samples of recycled paper sludge were collected from farmers' fields and analyzed for concentrations of NP1EO, NP2EO, 4-NP and 4-tOP. Each sample differed in the amount of time elapsed since the sludge was placed on farmers' fields. Primary degradation products of APEOs were present at low $\mu\text{g/g}$ concentrations in the sludge samples. Differences in the concentrations of these analytes in sludge samples indicated that APEO concentrations declined by 84% over a period of 14 weeks on farmers' fields. Changes in the chromatographic patterns of acetylated 4-NP indicated that there is a group of recalcitrant nonylphenol isomers that degrades more slowly than other isomers. These data indicate that microbial degradation may reduce the risk of environmental contamination by these compounds, but more work is required to assess the toxic potential of APEOs in sludges used for soil amendment.

ArticleTitle Levels, persistence and bioavailability of organic contaminants present in marine harbor sediments impacted by raw sewage.

Authors Hellou, J.; Mackay, D.; Banoub, J.

Journal Chemosphere. 1999, 38: 2, 457-473; 36 ref.

Abstract As part of a program to investigate the levels, fate and bioaccumulation of organic contaminants in a polluted marine harbour, organochlorine compounds including the polychlorinated biphenyls (PCBs), dichloro diphenyltrichloroethane and metabolites (DDTs), chlordanes, dibenzo-p-dioxins (Ds) and dibenzofurans (Fs), polycyclic aromatic hydrocarbons (PAHs) and sulphur hetero cycles were analysed in sediments spiked with St. John's Harbour sludge. Winter flounder (*Pseudopleuronectes americanus*) were exposed to these sediments containing six levels of harbour sludge during four winter months. Following exposure, sediments were reanalysed to investigate the persistence of the contaminants. The primary contaminants detected were PAHs ($\sim 5000 \text{ ng g}^{-1}$), predominantly alkylated phenanthrenes, fluoranthene and pyrene; PCBs with a predominance of Aroclor 1260 signature ($\sim 64 \text{ ng g}^{-1}$), DDTs ($\sim 5 \text{ ng g}^{-1}$), hepta and octachloro dioxins and furans ($\sim 0.5 \text{ ng g}^{-1}$) with very low levels of less chlorinated congeners. The PAHs degraded with an estimated half life of 2-3 months, while no significant degradation could be attributed to the other compounds. Bioaccumulation to muscle showed the potential uptake of contaminants in biota inhabiting the harbour. A concentration-response relationship was observed between spiked sediments and the concentrations of PCB congener 153 and unresolved congeners 138/163/164 in muscle. Of the dioxins and furans, only 2,3,7,8-tetrachlorofuran was detectable in muscle and at a similar concentration in all exposures indicating a similar bioavailability independent of the fraction of sludge in sediments. Of the PAHs, only naphthalene and methyl naphthalenes were detected in muscle, but did not display a concentration-response. One bile metabolite of pyrene was quantified and demonstrated metabolism. Biota-sediment accumulation factors were 0.2-7, indicating that equilibrium was approached, with the exception of the hepta and octachloro dioxins and furans which were not significantly bioaccumulated.

ArticleTitle Heavy metals from past applications of sewage sludge decrease the genetic diversity of *Rhizobium leguminosarum* biovar *trifolii* populations.

Authors Hirsch, P.R.; Jones, M.J.; McGrath, S.P.; Giller, K.E.

Journal Soil-biol-biochem. Exeter : Pergamon Press. Nov 1993. v. 25 (11) p. 1485-1490.

Abstract White clover plants grown at a site contaminated with heavy metals following applications of sewage sludge were found to have small white root nodules containing ineffective rhizobia (S isolates) which had identical plasmid profiles, unlike the diverse profiles of effective rhizobia from root nodules on adjacent control plots. Our paper supports an earlier suggestion that the ineffective S isolates of *Rhizobium* from nodules of white clover grown on heavy-metal contaminated soil represent a single strain. These new data include restriction fragment length polymorphism (RFLP) studies using probes specific for a chromosomally-located gene (*lac*), a plasmid-located symbiotic gene (*nifH,D*) and a repeated sequence specific for *Rhizobium leguminosarum* bv. *trifolii* (RtRS). RFLP patterns of isolates from control plots indicated that although these strains showed variation, they were related to one another but not to the S isolates. We also demonstrated that although the S isolates were ineffective on white clover, they formed normal nodules on subterranean clover, which were effective in nitrogen fixation. However, they ineffectively nodulated red clover and were unable to nodulate *Vicia hirsuta*. Thus the population of *R. leguminosarum* bv. *trifolii* had been radically altered by long-term exposure to heavy metal contamination, apparently losing those agronomically-important strains capable of forming effective symbiotic associations with white and red clover.

ArticleTitle Effects of an anionic surfactant, linear alkylbenzene sulfonate, on survival, reproduction and growth of the soil-living collembolan *Folsomia fimetaria*.

Authors Holmstrup, M; Krogh, P.H.

Journal Environmental Toxicology and Chemistry. 1996, 15: 10, 1745-1748; 16 ref.

Abstract A major component of sewage sludge is the detergent linear alkylbenzene sulfonate (LAS), found at concentrations of 4 to 10 g/kg dry matter. The effects of LAS on *Folsomia fimetaria* were investigated by use of a single species test system with 30 g soil spiked with LAS. Tests with either newly hatched individuals or adults (16-19 d old) were run for 3 weeks followed by extraction in a high-gradient extracting system. Juvenile mortality increased with increasing concns of LAS, whereas adult mortality was unaffected at the LAS levels tested (0-1000 mg/kg dry soil). Effective concn, 10%, values were estimated as 163 mg/kg for growth of juveniles, 185 mg/kg for molting frequency, and 147 mg/kg for reproductive output. Significant negative direct effects on populations of *F. fimetaria* may be expected at concns 8 to 20 times higher than those of sludge-amended soils.

ArticleTitle AIS/CESIO environmental surfactant monitoring programme. SDIA sewage treatment pilot study on linear alkylbenzene sulphonate (LAS)

Authors Holt, MS; Waters, J; Comber, MHI; Armitage, R; Morris, G; Newbery, C

Journal Water Research, vol. 29, no. 9, pp. 2063-2070, 1995

Abstract The outcome of a 7-day pilot monitoring study on the anionic surfactant, LAS, at the Yorkshire Water Service's Owlwood activated sludge sewage treatment works (STW) is described. The average concentration of LAS found in daily flow related composites of raw sewage was 15.1 mg l⁻¹ (range 11.8-18.2 mg l⁻¹). The calculated per capita use of the surfactant at Owlwood of 4.5 g/d/person agrees closely with the predicted use of LAS in Western Europe (ca 4.0 g/d/p). Distinct diurnal variations in the raw sewage LAS concentrations were observed (3.7-31.8 mg l⁻¹) and were apparent to a lesser degree in the treated effluent. The removal of the organic load (measured as BOD) and LAS at the works were both very high, 98 and 99.9% respectively. Hence, very low concentrations of LAS were discharged to the associated Sheffield Beck in the treated effluent (average daily composite of 10.4 µg l⁻¹). Unexpectedly, the river upstream of the discharge was found to contribute a higher load of LAS to the river downstream than the Owlwood effluent. The average daily composite LAS concentration in the river below the mixing zone of the STW was 27 µg l⁻¹ (range 9.4-47 µg l⁻¹). The concentrations of LAS found on sediments in the immediate vicinity of the STW were very small (< 1 µg g⁻¹). The implications of the study findings for the Standing Committee of Analysts (SCA) methodology used for the analysis of LAS and the design of further monitoring exercises on surfactants are discussed.

ArticleTitle Plant availability of heavy metals in soils previously amended with heavy applications of sewage sludge

Authors HOODA P S; MCNULTY D; ALLOWAY B J; AITKEN M N

Journal Journal of the science of food and agriculture, 1997 , 73 (4) 446-454

Abstract Plant uptake is one of the major pathways by which sludge-borne potentially toxic metals enter the food chain. This study examined the accumulation of Cd, Cu, Ni, Pb and Zn in wheat, carrots and spinach grown on soils from 13 sites previously amended with sewage sludge. Winter wheat, carrots and spinach were grown consecutively under field like conditions. The results showed that plant availability of heavy metals differed widely among the crop species. The accumulation of Cd, Ni and Zn in the plants showed the greatest increases compared to their background levels. The Cu and Pb accumulation in the plants grown on sludge-amended soils showed only small increases compared to those grown on uncontaminated soils. Multiple regression analysis of various soil properties showed that the surest way to control the accumulation of metals in food plants is by controlling their concentrations in the soils. Furthermore, soils with a non-acidic pH and a clayey texture tended to achieve better control of metal accumulation in food plants compared to those with an acidic reaction and a coarse texture. Metal concentrations in the plants generally correlated well with those extracted from soils in 0.005 M DTPA, 0.05 M EDTA-(Na) SUB 2 , 1 M NH SUB 4 NO SUB 3 and 0.05 M CaCl SUB 2 . The EDTA, however, proved to be a more reliable and consistent test in predicting the accumulation of metals in the plants. The results also showed that liming soils to pH 7 effectively reduced the metal contents in carrots and spinach, but liming to pH 6.5 had little effect on metal concentrations in wheat grain.

ArticleTitle Cadmium Solubility and Phytoavailability in Sludge-Treated Soil: Effects of Soil Organic Carbon

Authors Hyun, H.N.; Chang, A.C.; Parker, D.R.; Page, A.L.

Journal Journal of Environmental Quality, vol. 27, no. 2, pp. 329-334, Apr 1998

Abstract Slow mineralization of organic matter in sewage sludge-treated soil could release metals into more labile forms, which would then be more available for plant absorption. We examined the effect of soil organic matter decomposition on the phytoavailability of Cd in soils which, prior to this experiment, received 0 (control), 22.5, 45, 90, 180 Mg ha super(-1) yr super(-1) of sewage sludge for 6 yr. At the commencement of the experiment, one-half of the experimental plots continued to receive sewage sludge application at the prescribed rates. Sewage sludge application in the other half of the plots was terminated. All treated soils were cropped to Swiss chard (*Beta vulgaris*) twice each year for 10 yr and the soil was sampled after each crop harvest. When sewage sludge applications were terminated, the soluble Cd concentrations of the sludge-treated soil were higher than those in the control soils and did not decline significantly over the next 10 yr. With continuous sludge applications, the soluble Cd concentration of sludge-treated soils increased with each incremental addition of sludge for the same 10 yr. In soils receiving continuous sewage sludge inputs, the organic C content continued to rise with sludge inputs. After the termination of sludge application, organic C content of the sludge-treated soils decreased by approximately 40% over the 10-yr study. There was no indication that the soluble Cd concentration or the phytoavailability of Cd in the sludge-treated soils increased as the organic C in these soils declined over the 10 yr following termination of sewage sludge application.

ArticleTitle Differentiation of clover Rhizobium isolated from biosolids-amended soils with varying pH.

Authors Ibelwe, A.M.; Angle, J.S.; Chaney, R.L.; Van-Berkum, P.

Journal Soil Science Society of America. Nov/Dec 1997. v. 61 (6) p. 1679-1685.

Abstract Metal contamination may alter the diversity of microbes residing in soil. The genetic structure and phenotypic characteristics of clover Rhizobium isolated from contaminated and control soils were compared. Plant infection and symbiotic competence tests were used for phenotypic characterization. Variation across isolates in fingerprint patterns determined with primers for repetitive extragenic palindromic (REP) sequences and the polymerase chain reaction (PCR) were used for genetic characterization. Two phenotypic groups of effective and ineffective isolates were identified using the symbiotic effectiveness test. Soil pH was the primary factor influencing this phenotypic characteristic. Effective isolates were associated with higher soil pH and ineffective isolates were associated with lower soil pH regardless of soil metal content. The isolates were genetically diverse. The variation of isolates from the different soils overlapped, indicating that neither the heavy metals nor the low soil pH resulted in the selection of a single genotype. Isolates from the most heavily contaminated soils were more variable than isolates from control soils. Soil pH, and not heavy metal content, was important in the selection of rhizobia that formed ineffective N₂-fixing symbioses.

ArticleTitle An assessment of the risks associated with PCDDs and PCDFs following the application of sewage sludge to agricultural land in the UK.

Authors Jackson, A.P.; Eduljee, G.H.

Journal Chemosphere. Oxford : Pergamon Press. Dec 1994. v. 29 (12) p. 2523-2543.

Abstract

ArticleTitle Potting mixes - reservoirs of human fungal pathogens.

Authors Jeffery, S.; Foran, C.L.; Williams, E.A.; Ly, T.; Muir, D.B.; Roeber, R.U.

Journal Proceedings of the international symposium on growing media and plant nutrition in horticulture, Freising, Germany, 2-7 September 1996. Acta-Horticulturae. 1997, No. 450, 527-533; 27 ref.

Abstract Potting mixes manufactured from various recycled materials have the potential to support survival and growth of human opportunistic pathogens, such as, *Scedosporium* spp. These fungi cause mycetomas and chronic superficial and systemic infections of the central nervous and respiratory systems. As the incidences of serious mycotic infections caused by *S. apiospermum* and *S. prolificans* are increasing in Australia, there is a need to develop an effective technique to isolate them from the environment in order to ascertain their frequency. This is especially so from potting mixes, as they are increasingly associated with the environment of hosts, susceptible to fungal infections. A commercial potting mix, containing composted pine bark, peat and sewage-sludge, was inoculated with *S. apiospermum* in chopped Potato Dextrose Agar (PDA). The fungus was successfully isolated after 14 days incubation of the mix at 28°C. The antibiotics streptomycin, chloramphenicol and amphotericin B were shown not to suppress the growth of *S. apiospermum* and *S. prolificans* and could therefore be used in isolation media. Other antibiotic agents, namely furalaxyl, cycloheximide, and octoxynol at high concentrations in PDA, were shown to suppress growth of some strains of *S. apiospermum* and *S. prolificans*. An incubation temperature of 30-35°C may be more selective for the recovery of these fungi from the natural environment, as maximal colony growth of pure culture occurred on PDA at these temperatures.

ArticleTitle Fate and effects of linear alkylbenzene sulphonates (LAS) in the terrestrial environment.

Authors Jensen, J.

Journal Science of the Total Environment. 1999, 226: 2-3, 93-111; 4 pp. of ref.

Abstract Linear alkylbenzene sulphonates (LAS) are a group of anionic surfactants, characterised by having both a hydrophobic and a hydrophilic group. LAS is relatively rapidly aerobically degraded, but only very slowly or not at all degraded under anaerobic conditions. Therefore, LAS can be found in very high concentrations in most sewage sludge and enter the soil as a result of sludge application. LAS can be found in elevated concentrations in soil immediately after sludge amendment, but a half-life of approximately 1-3 weeks will generally prevent accumulation in soil and biota. The concentration in soils that have not received sewage sludge recently, is generally <1 mg/kg and not more than 5 mg LAS/kg. This is below the lowest concentration of LAS where effects have been observed in the laboratory. The laboratory data is in accordance with field studies using aqueous solutions of the sodium salt of LAS. However, observations of the ecological impact of sewage sludge applications or application of LAS spiked into sludge indicates a lower toxicity of LAS when applied in sludge. On the basis of the information reviewed in this paper, it is concluded that LAS can be found in high concentrations in sewage sludge, but that the relatively rapid aerobic degradation and the reduced bioavailability when applied via sludge, most likely will prevent LAS from posing a threat to terrestrial ecosystems on a long term basis.

ArticleTitle Effect of nursery application of sewage sludge on yield and heavy metal contents and uptake by rice (ADT 36) in the main field.

Authors Jeyabaskaran, K.J.; Sreeramulu, U.S.

Journal Journal of Environmental Biology 19 (1): p 43-47 1998

Abstract A field experiment was conducted on the seedlings of rice ADT 36 to study the possibility of reducing the dose of sewage sludge to be applied to the main field and also the contamination to the soil without sacrificing the grain and straw yields and nutrient and metal contents of rice crop. Seedlings were raised in two nursery plots-one without sludge application and another with sludge application @ 20 t ha⁻¹ (1.6 t/800 m²). The seedlings from both the treatments were transplanted separately in the main plots receiving 0, 25, 75 and 100 per cent of recommended dose (120 : 50 : 50 kg NPK ha⁻¹) of mineral fertilizer. The yields of grain and straw of the sludged seedlings receiving 75 per cent mineral fertilizer was on par with that of unsludged seedlings receiving 100 per cent mineral fertilizer. Similar influence was also observed with regard to the content and uptake of nutrients and heavy metals by the crop. No toxic effects of heavy metal contamination on soil or in grains were noticed in this study, Hence this method helps to reduce the mineral fertilizer requirement by 25 per cent and also avoid addition of heavy metals to the main field.

ArticleTitle Urban organic waste in agriculture - risk or resource?

Authors Johansson, M.

Journal Acta Universitatis Agriculturae Sueciae - Agraria (No. 178): 35 pp., 1999, 5 pp of ref.

Abstract This thesis examines the effect of adding organic waste, in the form of manures and sewage sludges, on several microbiological soil properties. The microbiological parameters assessed were basal respiration, substrate-induced respiration, nitrogen mineralisation, nitrification, denitrification and phosphatase activity. The effects of freezing and cold storage on the microbiological analyses used were evaluated. Freezer storage for a period of 13 months did not affect the microbial biomass or its activities. However, storage for more than 13 months cannot be recommended. Process kinetics have the potential to describe processes as well as to give increased understanding and more detailed knowledge of the functioning of the soil ecosystem. In addition, it can increase the sensitivity of the methods used. New kinetic ideas regarding substrate-induced respiration and denitrification were evaluated and validated at laboratory scale using a silver-contaminated soil. The approach was useful and allowed early detection of changes in the parameters investigated. To study the potential of the microbial tests in monitoring the quality of organic wastes, well-characterised sewage sludges and manures were selected and tested in the laboratory. Generally, both biomass and activity increased with increasing rate of organic amendment. Although the influence of added organic material was strong, it was possible to distinguish between the effects of sludges. In most cases it was also possible to relate these differences to the content of heavy metals in the sludges. Long-term effects of sewage sludge amendments were monitored in a field experiment after 12 and 16 years of sludge addition. Long-term sludge addition affected several of the parameters investigated, biological as well as chemical. However, no severe negative effects on soil microorganisms were detected at these moderate levels of sludge amendment.

ArticleTitle Special issue: organic contaminants in sewage sludge.

Authors Jones, K. (ed.); Alcock, R.

Journal Science of the Total Environment. 1996, 185: 1-3, 222 pp.; ref. at end of papers.

Abstract Papers given at the International Symposium on Organic Contaminants in Sewage Sludges, held at Lancaster University, UK, 16-17 May, 1995, are presented. Topics include: (i) sources, behaviour and fate of organic contaminants during sewage treatment; (ii) monitoring and prioritization of organic contaminants in sewage sludges using specific chemical analysis and predictive, non-analytical methods; (iii) screening the environmental fate of organic contaminants in sewage sludges applied to agricultural soils; (iv) organic compounds in sludge-amended soils and their potential for uptake by crop plants; (v) bioaccumulation and metabolic fate of sewage sludge derived organic xenobiotics in plants; (vi) ingestion of sludge applied organic chemicals by animals; (vii) polychlorinated dibenzo-p-dioxins and dibenzofurans in sewage sludge: sources and fate following sludge application to land; (viii) the form and bioavailability of non-ionic organic chemicals in sewage sludge-amended agricultural soils; (ix) organotin compounds in municipal waste water and sewage sludge: contamination, fate in treatment process and ecotoxicological consequences; (x) a review of the interaction of surfactants with organic contamination in soil; (xi) effects assessments for surfactants in sludge-amended soils; a literature review and perspectives for terrestrial risk assessment; and (xii) organic contaminants in municipal biosolids: risk assessment, quantitative pathways analysis, and current research priorities.

ArticleTitle Dioxins and furans in sewage sludges: a review of their occurrence and sources in sludge and of their environmental fate, behavior, and significance in sludge-amended agriculture systems.

Authors Jones, K.C.; Sewart, A.P.

Journal Critical Reviews in Environmental Science and Technology. 1997, 27: 1, 1-85; many ref.

Abstract This review on polychlorinated dibenzo-p-dioxins and -furans (PCDD/F) in sewage sludge and their significance for the environment includes data on the transfer of these contaminants from sludged soil into the food chain and the role of food as a major factor in human intake of PCDD/F. A contamination pathway assessment procedure is presented focusing on transfer of PCDD/F into milk and meat from pasture based on total toxic equivalents, and designed for dairy and beef cattle separately. An assessment of the influence of unsludged rural and urban and worst-case sludge scenarios for human PCDD/F exposure (including dietary exposure) is also presented.

ArticleTitle The potential for contamination of soil and surface waters from sewage sludge (biosolids) in a sheep grazing study, Australia.

Authors Joshua-WD; Michalk-DL; Curtis-IH; Salt-M; Osborne-FGJ; Naidu-R

Journal Special issue. Contaminants and the soil environment. Geoderma. 1998, 84: 1-3, 135-156; 16 ref.

Abstract Dewatered biosolids (DWB) were applied at 0-120 dry t/ha to 3 types of soils in a sheep grazing trial at Goulburn and over a period of 1.5 years data were gathered on the surface and subsurface movement of nutrients and metals in the runoff water and soil profile, respectively. The biosolids reduced runoff and increased surface retention of rainfall. Data show environmentally insignificant concentrations of metals in the runoff waters whereas nitrate concentrations were significantly greater compared with control plots. Zinc and copper moved in the upper 30 cm of the soil profile, whereas nitrates moved down the soil profile to a depth of 50 cm in the duplex soils and 70 cm in the sandy red earths. Subsurface lateral movement of nitrates was observed in one duplex soil on the 60 and 120 dry t/ha treatments and was significant in the higher rate. Surface and subsurface movement of nitrate and some metals were detected in the trial. However, the actual amounts of these plant nutrients were low and almost negligible in treatments applied at rates of 30 dry t/ha.

ArticleTitle Devitalization of bacterial and parasitic germs in sewage sludge during aerobic digestion under laboratory conditions.

Authors Juris, P.; Plachy, P.; Laukova, A.

Journal Veterinari-Medicina. 1995, 40: 5, 157-162; 11 ref.

Abstract The survival of 5 bacterial species (*Pseudomonas* sp., *Salmonella* sp., enterobacteria, *Streptococcus* sp., *Escherichia coli*) was determined in municipal sewage sludge for up to 37 h of mesophilic aerobic digestion under laboratory conditions. The model strain *Enterococcus faecium* CCM 4231 survived almost twice as long as the above-mentioned isolates. Similar findings, regarding the viability of the microorganisms studied, were also determined during thermophilic aerobic digestion of municipal sewage sludge. The final reduction in the total count of bacteria was not directly dependent on the temperature during aerobic digestion. It is suggested that the *E. faecium* CCM 4231 strain (a bacteriocin-producing strain with a broad antimicrobial spectrum), when inoculated into sludge, could inhibit the growth of microorganisms in the sludge as a result of its bacteriocin activity. During the thermophilic digestion process all helminth eggs (*Ascaris suum*, *Toxocara canis*) were killed. All eggs of *T. canis* were killed in experiments under mesophilic temperature, but 32% of non-embryonated *A. suum* eggs remained viable.

ArticleTitle Rare earth elements and other trace elements in wastewater treatment sludges.

Authors Kawasaki, A.; Kimura, R.; Arai, S.

Journal Soil Science and Plant Nutrition. 1998, 44: 3, 433-441; 26 ref.

Abstract The contents of rare earth elements (REEs; La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu) and other trace elements (Be, As, Ag, Cd, Sb, Cs, Bi, and U) in waste water treatment sludges were determined. In night-soil sludges and sludges of waste water treatment plants in the food industry, the distribution patterns of REEs normalized vs. average REEs were almost flat. It was considered that the REE patterns of uncontaminated sludges reflected the pattern of the continental crust. The crust-normalized REE patterns of sludges of waste water treatment plants in the chemical industry and municipal sewage sludges did not always show flat plots. The sludges that did not show a flat REE pattern were considered to be contaminated with some of the REEs. The coefficient of variation of each element determined among the 10 samples of night-soil sludges and the 14 samples of sewage sludges ranged from 34 to 77% and from 26 to 84%, respectively. Among the 10 samples of food industry sludges and the 10 samples of chemical industry sludges, the coefficient ranged from 60 to 143% and from 67 to 172%, respectively. The variations of the content of each element among the food industry sludges or the chemical industry sludges were larger than those among the night-soil sludges or the sewage sludges. The contents of Be, As, Cs, REEs, and U in all the sludges were lower than or the same as those in a field soil. Some of the food and chemical industry sludges contained larger amounts of Ag, Cd, and Sb than the soil. All the night-soil sludges and sewage sludges contained much larger amounts of Ag and Bi than the soil.

ArticleTitle Accumulation and persistence of chlorobiphenyls, organochlorine pesticides and faecal sterols at the Garroch Head sewage sludge disposal site, Firth of Clyde.

Authors Kelly, A.G.

Journal Environmental Pollution. 1995, 88: 2, 207-217; 3 pp. of ref.

Abstract The sediment concn of organic carbon, faecal sterols, individual chlorobiphenyl congeners and organochlorine pesticides were measured in seabed cores from the sewage sludge disposal area at Garroch Head in the Firth of Clyde, UK. The measurements confirmed the accumulative nature of the site with high levels of sedimentary faecal sterols (152 mg/k coprostanol). Levels of chlorobiphenyls, DDT compounds and dieldrin in surface sediments were elevated by factors of 12, 40 and 120, resp., over those observed at a site remote from the effects of dumping. Total chlorobiphenyl levels of 515 mug/kg Arochlor 1254 in surface sediment were comparable to levels found in other areas heavily contaminated with sewage sludge. The 20 cm depth of heavily sludge-contaminated sediment overlays a mixed sludge/basal sediment layer some 10 cm in depth. Levels of organochlorine contaminants were elevated to depths of 90 cm in the sediment, suggesting that the surface layer is a source of contaminants to the deeper sediment. Within the upper 15-20 cm sediment in the disposal area, chlorobiphenyls were conservative, the variation in their concn with respect to depth being related to historical input. Lindane and possibly dieldrin, and hexachlorobenzene were not conservative. Faecal sterols were removed in sub-surface sediment, in contrast to conservative behaviour previously found at other sewage-polluted sites.

ArticleTitle Effects of heavy metal contamination and remediation on soil microbial communities in the vicinity of a zinc smelter.

Authors Kelly, J.J.; Tate, R.L.-III.

Journal Journal of Environmental Quality. Madison : American Society Of Agronomy,. May/June 1998. v. 27 (3) p. 609-617.

Abstract Heavy metal contamination can impact soil ecosystems sufficiently to result in significant losses in soil quality. The negative impact of heavy metals results from their toxicity to biological processes, including processes catalyzed by soil microorganisms. Therefore, it is postulated that the soil microbial community could serve as an indicator of losses in soil quality due to heavy metal contamination and of changes in soil quality resulting from reclamation. In this study, the size, activity, and structure of microbial communities from remediated and unremediated soils in the vicinity of a Zn smelter were evaluated. Both total and soluble metal loadings in these soils increased with proximity to the smelter. Indicators of microbial activity (dehydrogenase activity) and viable population size (plate counts) were negatively affected by the elevated metal levels. Microbial community structure also varied with increasing contamination, as indicated by cluster analysis and principal component analysis of BIOLOG community metabolic profiles. Remediated soils at this site were treated by surface application of a mixture of sewage sludge and fly ash. Remediation resulted in a decrease in soluble metals and an increase in indicators of biological activity and viable population size. Remediated soils also showed metabolic profiles that were more similar to the least contaminated site, suggesting recovery of the microbial populations. These data suggest that the microbial community may be a useful indicator of changes in soil quality with management of these highly contaminated soils.

ArticleTitle Sorption and biodegradation of nonionic surfactants by activated sludge.

Authors Kiewiet, A.T.; Weiland, A.R.; Parsons, J.R.

Journal Recent advances in ecotoxicology. Proceedings of the 2nd European conference on ecotoxicology, Amsterdam, Netherlands, 11-15 May, 1992. Science-of-the-Total-Environment. 1993, No.SUP-93, 417-429; 18 ref.

Abstract The relationship between sorption and biodegradation of surfactants was investigated by comparing the biodegradation in water with and without added sterilized activated sludge. It appeared that the biodegradation of nonionic surfactants was not inhibited by the presence of sterilized activated sludge, although the disappearance of the nonionic surfactant was slower in the sludge than in the water phase.

ArticleTitle Effects assessments for surfactants in sludge-amended soils: a literature review and perspectives for terrestrial risk assessment.

Authors Kloepper-Sams, P.; Torfs, F.; Feijtel, T.; Gooch, J; Jones, K. (ed.); Alcock, R.

Journal Organic contaminants in sewage sludges. Proceedings of International Symposium, Lancaster University, UK, 16-17 May 1995. Science-of-the-Total-Environment. 1996, 185: 1-3, 171-185; 63 ref.

Abstract A review of the literature on the sorption of detergent surfactants to sludge solids, during waste water treatment, and to soil components indicated that toxicity data for invertebrates and numerous higher plants are available for the anionic surfactant linear alkyl benzene sulfonate (LAS). Different modes of exposure (hydroponic medium, addition to irrigation water, spiked soil, spiked sludge) and types of soil significantly impacted toxicity test results and must be taken into account when performing a risk assessment. The extrapolation of aquatic toxicity data to derive terrestrial PNECs (predicted no effect concentrations) is discussed. The development of practical chronic testing, such as the rapid cycling Brassica plant life-cycle test, is discussed in the context of the various tiered testing approaches currently proposed by different regulatory agencies.

ArticleTitle Environmental hazard assessment of chemicals and products. V. Anthropogenic chemicals in sewage sludge.

Authors Klopffer, W.

Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. Sept 1996. v. 33 (6) p. 1067-1081.

Abstract

ArticleTitle Trace analysis of surfactants in sewage sludges and soils

Authors Klotz, H

Journal Tenside, Surfactants, Detergents, vol. 35, no. 6, pp. 459-463, Dec 1998

Abstract The trace analysis of surfactants in sewage sludges and soils involves considerable effort in taking, preparing and working up samples. In robust screening procedures conventional chromatography with non-specific detection is used. If required, these methods can be augmented and validated by mass-spectroscopic techniques. Current industrial practice for the determination of surfactant traces in sewage sludge and fields fertilised with it, as well as in suspended solids and sediments in rivers is described. The emphasis is on conventional equipment and procedures. The term surfactant includes anionics (e.g. LAS, AES, SAS), nonionics (e.g. AE, APE) and cationics (e.g. DCDMAC, Ester Quats).

ArticleTitle Microbial mineralization of organic compounds in an acidic agricultural soil: effects of preadsorption to various soil constituents.

Authors Knaebel, D.B.; Federle, T.W.; McAvoy, D.C.; Vestal, J.R.

Journal Environmental Toxicology and Chemistry. Pensacola, Fla. : SETAC Press. Nov 1996. v. 15 (11) p. 1865-1875.

Abstract This study investigated the interactions between organic chemicals and components of the soil matrix and their effects on subsequent microbial mineralization kinetics. Five ¹⁴C-labeled chemicals (anionic, cationic, and nonionic surfactants) were aseptically sorbed to montmorillonite, kaolinite, illite, sand, humic acids, and fulvic acids. Small amounts of these sorbed chemicals were dosed to an acidic, sludge-amended agricultural soil (Rossmoyne) to a final added chemical concentration of 50 ng g⁻¹. Controls received the same final added concentration of the chemicals in water. The ratio of sorbed chemical to soil was kept low to minimize changes to the soil mineralogy, chemistry, and microbiology. Microbial mineralization of the chemicals to ¹⁴CO₂ was measured over a period of 60 to 70 d, and the data were fitted to first-order and 3/2-order mineralization models. Association with the soil constituents inhibited the mineralization of the chemicals in the following rank (from least to greatest effect): controls approximately sand < kaolinite < illite < montmorillonite approximately humic acids < fulvic acids. These experiments demonstrated that interactions with some soil constituents (kaolinite, illite, and sand) had little effect on the microbial metabolism of these chemicals, while montmorillonite, humic acids, and especially fulvic acids significantly decreased the bioavailability of the chemicals to the microbial community. The first group of soil constituents had little influence on the mineralization kinetic parameters, whereas the latter significantly reduced at least one of the parameter estimates. The parent soil, possibly via interactions with its mineral surfaces, also had effects on the degradation of the chemicals, since soil microbial biomass and physiological activity were not correlated with any of the mineralization kinetic parameter estimates. These experiments demonstrate that the environmental form of a chemical has a significant influence on its eventual microbial metabolism and is an important parameter to consider when investigating the fate of chemicals in soil environments.

ArticleTitle Determination of the adsorption-coefficients of organic substances on sewage sludges.

Authors Kordel, W.; Hennecke, D.; Franke, C.

Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. July 1997. v. 35 (1/2) p. 107-119.

Abstract

ArticleTitle Feasibility study of the applicability of the activated sludge process to treatment of radioactive organic liquid waste

Authors Koyama, A.; Nishimaki, K.

Journal Waste Management (United Kingdom) 1997 , 17/1 (47-52) No Ref: 10

Abstract We used an activated sludge process to treat radioactive organic liquid waste. Organic liquid waste is difficult to treat by conventional radioactive liquid treatment processes, but in order to reduce long-term irradiation of the public the removal of radionuclides from such waste is preferable to dilution. Activated sludge processes are widely used for the biological treatment of sewage and are considered appropriate means for treating radioactive organic liquid waste. In this process, the fate of radionuclides eluted by treated water or immobilized by activated sludge, is extremely important for public safety and for the treatment of radioactive organic liquid waste. We performed uptake and desorption behavior experiments on the three short half-life radionuclides ¹³⁷Cs, ⁹⁰Sr, and ⁶⁰Co, and used three nutritive types of artificial sewage as the feed solution. On the basis of the results, we discuss the uptake-desorption behavior of these radionuclides in an activated sludge process. We conclude that treatment of radioactive organic liquid waste by an activated sludge process is possible, but improvements must be made in the process if it is to be more effective.

ArticleTitle Transferable resistance to gentamicin and other antibiotics in Enterobacteriaceae isolates from municipal wastewater

Authors Kralikova, K.; Krcmery, V.; Krcmery, V., Jr.

Journal J. Hyg. Epidemiol. Immunol Vol. 28, No. 2 , pp. 161-166, 1984

Abstract In two sets of Enterobacteriaceae and Pseudomonas bacteria resistant to at least two antibiotics a distinctly upward trend was found in the incidence of strains resistant to gentamicin. Gentamicin resistance transfer could be demonstrated in a sewage sludge strain of Klebsiella pneumoniae resistant to seven antibiotics and in two multiresistant isolates from the river Danube. Resistance transfers in the case of other antibiotics, especially those susceptible to beta-lactamase (ampicillin, carbenicillin), were demonstrated in 10 out of the 24 di- and multiresistant strains tested. The findings show that both municipal wastewater and water in streams may function as the reservoirs of strains bearing the determinants of transferable resistance. Such strains may play an important role not only in the ecology and epidemiology of R plasmids, but also in the accidental spread of the so-called DNA recombinants that might escape during gene manipulations.

ArticleTitle Evaluation of Methodology for Quantifying Radiopharmaceuticals in Tertiary-Treated Sewage

Authors Krieger, H.; Frishkorn, G.; Martin, E.; Jacobs, B.

Journal Effluent & Environmental Radiat. Surveillance pp. 20-28 , 1980

Abstract The production and utilization of radioactive pharmaceuticals and radionuclides for medical diagnosis and therapy warrant consideration of their fate and their radiation hazard to the population after discharge. Even after tertiary treatment operations, many of these radionuclides will still be present. This tertiary treatment is necessary when sewage effluents are to be used as coolants for nuclear reactors, and the confirmation of these nuclides in these effluents becomes of major concern as possible radiation hazards.

ArticleTitle Biosolids and sludge management

Authors Krogmann, U; Boyles, LS; Martel, CJ; McComas, KA

Journal Water Environment Research, vol. 69, no. 4, pp. 534-550, Jun 1997

Abstract An overview about wastewater sludges, biosolids use, and disposal worldwide was edited by Matthews (1996). To compare different practices, each country reported their beneficial use and disposal practices of a "benchmark" sludge for a population of 100,000 with mixed urban contributions. An emphasis of the report was regulatory practices worldwide. Witter (1996) discussed the Swedish Environmental Protection Board's aims to decrease the metal load of soils until a situation of zero accumulation is reached. With the possible exception of cadmium, he saw no evidence to suggest that zero accumulation of metals in soils is required to protect soil productivity, the environment, or human and animal health. However, the policy also recognized the practically irreversible nature of elevated heavy metal concentrations and their effects in soil, the deficiencies of the evidence currently available to establish safe metal loadings for soils, as well as the need to preserve the agronomic values of soils. Davis (1996) predicted that land application of biosolids and incineration will be the major disposal options for the future in the United Kingdom (U.K.) and Europe. Furthermore, environmental pressures on biosolids recycling through land applications may lead to restrictions in terms of nitrogen applied and more stringent limits for metals in soils.

ArticleTitle Biosolids and sludge management
Authors Krogmann, U; Qu, Mingbo; Boyles, LS; Martel, CJ
Journal Water Environment Research, vol. 70, no. 4, pp. 557-580, Jun 1998
Abstract Goldstein (1997) conducted a survey of state biosolids coordinators in the U.S. providing insights into management practices, regulation development, and acceptance of administering the federal 40 Code of Federal Regulations (CFR) Part 503 rule. The survey showed a general trend of an increase in the beneficial use of biosolids and a need for more outreach. This increase of beneficial use of biosolids in the U.S. was confirmed by Bastian (1997). A survey among the largest municipal wastewater treatment facilities in the U.S. responsible for a sewer population of approximately 65 million people indicated that 87.5% of biosolids currently comply with 40 CFR Part 503.

ArticleTitle Biosolids and sludge management
Authors Krogmann, Uta; Boyles, Lisa S; Bamka, William J; Chaiprapat, Sumate; Martel, CJ
Journal Water Environment Research, vol. 71, no. 5, pp. 692-714, 1999
Abstract The biosolids and sludge management are discussed. This include regulation and planning; reduction of biosolids and sludge production; biosolids and sludge characteristics; synthetic organics; storage; pumping; thickening; conditioning; dewatering; heat drying; combustion; pyrolysis; determination of the degree of stabilization and pathogen and vector attraction reduction; aerobic digestion; anaerobic digestion; composting; land application; landfilling; and ocean disposal.

ArticleTitle Endocrine Disrupters in Municipal Sewage Sludge-The Example of Organotin Compounds
Authors Kuballa, J., Jantzen, E.; Steffen, D.
Journal Boden p30(3) Sep 98
Abstract Samples of sewage sludge were collected in 1994 and 1996 from nine municipal water treatment plants in Germany. The samples were evaluated for their contents of potentially toxic organotin compounds, including originate from anti-fouling paints, biocides, and PVC materials. All of the samples collected as part of this project exhibited some amounts of organotin compounds. The highest concentration levels in the samples are described, and the implications for public health are discussed. Future research needs and legislative actions on these issues are proposed.

ArticleTitle Endocrine disrupters in municipal sewage sludge - the example of organotin compounds
Authors Kuballa, J; Jantzen, E; Steffen, D
Journal Wasser und Boden, vol. 50, no. 10, pp. 30-32, Oct 1998
Abstract In 1994 and in 1996, sewage sludge samples from 9 municipal water treatment plant were analyzed for toxic organotin compounds, such as originate from anti-fouling paints, but also biocides and PVC materials. All samples contained organotin compounds, some at very high concentrations. The need for further studies and amendments to existing regulations are discussed.

ArticleTitle Behaviour of linear alkylbenzene sulphonates (LAS) in sandy soils with low amounts of organic matter.
Authors Kuchler, T.; Schnaak, W.
Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. July 1997. v. 35 (1/2) p. 153-167.
Abstract

ArticleTitle Biodegradability of the anti-tumour agent ifosfamide and its occurrence in hospital effluents and communal sewage

Authors Kuemmerer, K; Steger-Hartmann, T; Meyer, M

Journal Water Research, vol. 31, no. 11, pp. 2705-2710, Nov 1997

Abstract A portion of administered pharmaceuticals are excreted unmetabolised by patients and can be found in hospital effluent and municipal sewage. Some pharmaceuticals such as anti-tumour agents are carcinogenic, mutagenic, teratogenic and fetotoxic. Little is known about their environmental impact. Therefore, the biodegradability of the widely used anti-tumour agent ifosfamide (IF) was assessed with the modified Zahn-Wellens test (OECD 302 B) and a test simulating biological sewage treatment. The biodegradation was monitored by DOC and GC/MS. The concentration of IF in hospital effluent, communal sewage and the effluent from a communal sewage treatment plant (STP) was analysed as well as calculated by the amounts of water and IF used in hospitals. The expected concentration of IF in German surface waters was calculated. IF was not biodegradable in the Zahn-Wellens test and the STP simulation test. It was not adsorbed by the sewage sludge. The concentrations measured in the hospital effluents, the STP influent and the STP effluent were of the same order of magnitude as the calculated ones, indicating that no adsorption, biodegradation or other elimination of IF took place to any noticeable extent.

ArticleTitle Behavior and fate of surfactants in soil.

Authors Kuhnt, G.

Journal Environmental Toxicology and Chemistry. Tarrytown, N.Y. : Pergamon Press. Oct 1993. v. 12 (10) p. 1813-1820.

Abstract

ArticleTitle Review of Analytical Methods for the Determination of Nonylphenol and Related Compounds in Environmental Samples

Authors Lee, H-B

Journal Water Quality Research Journal of Canada, vol. 34, no. 1, pp. 3-35, 1999

Abstract Analytical methods published in the last 20 years for the extraction, chromatographic separation, and quantification of alkylphenol ethoxylates (APEO) and related compounds in environmental samples are reviewed. Examples of various isolation and preconcentration techniques for water, effluent, sediment and sludge are presented. This includes procedures from the classical liquid-liquid and Soxhlet extraction to the up-to-date solid phase and supercritical fluid extraction. Chromatographic separation of APEO by normal and reversed phase liquid chromatography (LC) and capillary column gas chromatography (GC) is compared. A variety of quantification methods involving the common LC and GC detectors as well as various mass spectrometric techniques are also discussed.

ArticleTitle Determination of 4-nonylphenol in effluent and sludge from sewage treatment plants.

Authors Lee, H-B; Peart, T.E.

Journal Analytical Chemistry, Washington. 1995, 67: 13, 1976-1980; 20 ref.

Abstract A method for the determination of 4-nonylphenol (4-NP) in sewage treatment plant effluent and sludge samples is described. For effluent, the 4-NP was converted, in situ, into its acetyl derivative with acetic anhydride in the presence of a base. For sewage sludge, 4-NP was subjected to supercritical carbon dioxide extraction and on-line acetylation during the extraction stage. After a silica gel column cleanup, sample extract was analysed by GC on a 0.25 μm HP-5-MS column (30 m x 0.25 mm), operated with temperature programming, helium as carrier gas, and MS detection in the selected ion mode. Recoveries of 4-NP in spiked samples were >93%. Detection limits for 4-NP were 0.1 $\mu\text{g/litre}$ for effluent and 0.1 $\mu\text{g/g}$ for sludge. The methods were applied to the determination of 4-NP in samples collected from sewage treatment plants in the vicinity of Toronto, Canada. Conc of 4-NP from <1 to 30 $\mu\text{g/litre}$ in the effluent and >100 $\mu\text{g/g}$ in sludge were found.

ArticleTitle Review of analytical methods for the determination of nonylphenol and related compounds in environmental samples

Authors Lee, Hing-Biu

Journal Water Quality Research Journal of Canada, vol. 34, no. 1, pp. 3-35, 1999

Abstract NPEs are discharged into the environment primarily from textile and pulp and paper production-facilities. They are also used in coal processing, latex paints, grease and lubricating oils, pesticides and industrial detergents. Acute adverse effects have been reported in invertebrates, fish, mammals and algae. There are also concerns that these substances may interfere with endocrine function. An assessment is required to determine exposure levels and the risk they may pose to the environment and human health in Canada. Analytical methods published in the last 20 years for the extraction, chromatographic separation, and quantification of alkylphenol ethoxylates (APEO) and related compounds in environmental samples are reviewed. Examples of various isolation and preconcentration techniques for water, effluent, sediment and sludge are presented. This includes procedures from the classical liquid-liquid and Soxhlet extraction to the up-to-date solid phase and supercritical fluid extraction. Chromatographic separation of APEO by normal and reversed phase liquid chromatography (LC) and capillary column gas chromatography (GC) is compared. A variety of quantification methods involving the common LC and GC detectors as well as various mass spectrometric techniques are also discussed.

ArticleTitle Occurrence and elimination of nonylphenol ethoxylates and metabolites in municipal wastewater and effluents

Authors Lee, Hing-Biu; Peart, T.E.

Journal Water Quality Research Journal of Canada, vol. 33, no. 3, pp. 389-402, 1998

Abstract A survey of the concentrations of nonylphenol ethoxylates (NPnEO) and their metabolites in wastewater samples collected from a Canadian sewage treatment plant using primary and secondary treatment is presented. Twenty-four-hour composite raw sewage, primary effluent and final effluent samples were collected monthly over a one-year period. Levels of NPnEO (n = 1 to 17) and their metabolites, nonylphenol (NP) and nonylphenoxy carboxylic acids (NPnEC), in these samples were determined by HPLC and GC/MS methods. While ca. 85% of the total alkylphenolics in raw sewage are ethoxylates, the major component (nearly 80%) in the final effluent was in the form of carboxylic acids. During this study period, the median total alkylphenolic concentrations in raw sewage and final effluent were 526 and 248 nmol/L, respectively, representing an overall elimination rate of 53%. The estimated daily discharge of the nonylphenolics to the aquatic environment varied from 15 to 44 moles, with a median value of 20 moles. These data suggested that conventional sewage treatments are ineffective in the removal of the surfactant-derived metabolites.

ArticleTitle Determination of nonylphenol polyethoxylates and their carboxylic acid metabolites in sewage treatment plant sludge by supercritical carbon dioxide extraction

Authors Lee, Hing-Biu; T.E. Peart; D.T. Bennie; R.J. Maguire

Journal Journal of Chromatography 785 385-394 1997

Abstract

ArticleTitle Occurrence of alkylphenoxyacetic acids in Canadian sewage treatment plant effluents

Authors Lee, Hing-Biu; Weng, Jianhua; Peart, TE; Maguire, RJ

Journal Water Quality Research Journal of Canada, vol. 33, no. 1, pp. 19-29, 1998

Abstract Alkylphenoxyacetic acids such as 4-tert-octylphenoxyacetic acid (OP1EC) and nonylphenoxyacetic acid (NP1EC) are metabolites of non-ionic surfactants derived from the ethoxylation of 4-tert-octylphenol (OP) and nonylphenol (NP). Although the occurrence of OP1EC and NP1EC was suspected in many Canadian sewage treatment plant effluents due to the extensive use of the alkylphenol ethoxylate surfactants and their degradation under sewage treatment conditions, the acids have never been reported due to the lack of authentic standards. In this work, OP1EC and NP1EC were synthesized by the condensation of OP and NP, respectively, with chloroacetic acid in the presence of a base. With these standards, the occurrence of OP1EC and NP1EC in Canadian sewage treatment plant effluents was confirmed for the first time. The level of OP1EC ranged from 0.18 to 1.2 µg/L and from 0.45 to 6.8 µg/L, in the primary and final effluents, respectively. In contrast, the level of NP1EC in the same sample was much higher and it ranged from 2.4 to 17.7 µg/L in the primary effluents and from 3.2 to 703 µg/L in the final effluents.

ArticleTitle Development of soil metal criteria to preserve groundwater quality.

Authors Lee, SuenZone; Chang, LiZone; Chen, ChienMin; Liu, MingChou; Tsai, LiJyur; Lee, S.Z.; Chang, L.Z.; Chen, C.M.; Liu, M.C.; Tsai, L.J.; Grabow, W.O.K.; Dohmann, M; Haas, C; Hall, E.R.; Lesouef, A; Orhon, D; Vlies, A; van der Watana be, Y; Milburn, A; Purdon, CD; Nagle, PT

Journal Water Quality International '98. Part 9. Water quality: management. Selected Proceedings of the 19th Biennial Conference of the International Association on Water Quality, Vancouver, BC, Canada, 21-26 June 1998. Water-Science-and-Technology. 1998, 38: 11, 131-139; 11 ref.

Abstract The principal impediment in the remediation of contaminated sites and in the protection of groundwater quality is the lack of appropriate and reasonable standards for heavy metals in soils. There are no standards applicable to predict the potential for groundwater contamination by heavy metals in Taiwan. Lack of these soil standards may result in subjective judgment regarding the remediation needed. The migration of heavy metals through the unsaturated zone to groundwater is controlled by sorption to the soil, a highly pH-dependent process, and the hydrological regime. Soil sorption behaviour is the criterion upon which to establish a standard based on a maximum permissible concentration in groundwater. The maximum level of metal in soil for which the equilibrium soluble metal does not exceed the Drinking Water Standard can be computed, at any pH, from the measured adsorption coefficient for any metal and soil. These metal criteria can be used as soil standards that will be protective of groundwater quality. Criteria for soil remediation are based on specific soil types and the effect of pH on metal sorption because the partitioning of trace metals is highly dependent on the solution pH and the chemical nature of the soil.

ArticleTitle Biodegradation of trace levels of a complex organic pollutant mixture.

Authors Limbert, E.S.B.; Betts, W.B.

Journal Microbios. 1994, 78: 317, 237-243; 8 ref.

Abstract Three bacterial isolates with the ability to grow on a model mixture of groundwater contaminants were obtained from a sewage works for treatment of industrial effluents, and from heavily and intermediately contaminated ground. The mixture consisted of benzene, toluene, o-xylene, nitrobenzene, 1,4-dichlorobenzene, o-cresol, naphthalene, tetrachloromethane and trichloroethylene, at concn ranging from 150 to 600 µg/litre (2.1 mg/litre in total). A supplement of 50 mg/litre phenol was added to support growth and batch cultures were adapted for 6 weeks. Preliminary assays to check for degradative ability and toxicological assessments of the compounds using oxygen uptake rates were undertaken. Each isolate exhibited a different extent of degradation for the various compounds. In 18 h incubation, from an initial figure of 1,966 µg/litre (not including the primary substrate) the highest remaining total organic carbon of 800 µg/litre was for the isolate from activated sludge. The effect of the organic compounds upon oxygen uptake rate was less marked for the microorganisms from heavily polluted ground.

ArticleTitle Proficiency testing for dioxin laboratories determination of polychlorinated dibenzo-p-dioxins and dibenzofurans in sewage sludge.

Authors Lindig, C.

Journal Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. Aug 1998. v. 37 (3) p. 405-420.

Abstract

ArticleTitle The influence of surfactants applied by sewage sludge on the behaviour of atrazine and PAHs in semiarid soils.

Authors Litz, N; Muller-Wegener, U.

Journal Zeitschrift fur Pflanzenernahrung und Bodenkunde. 1998, 161: 3, 255-259; 21 ref.

Abstract The effect of two surfactants applied via sewage sludge: LAS (linear alkylbenzene sulfonate) and nonylphenol as a metabolite of nonylphenol ethoxylate, on PAHs (polycyclic aromatic hydrocarbons) and atrazine mobility was investigated in an Egyptian Vertisol and a Gypsisol treated with sewage sludge. In both cases the surfactants promoted the leachability of atrazine only moderately compared to the untreated plot. PAHs were leached from the surface layer (0-20 cm) into the 20-50 cm layer during the three month test period. Relatively higher leaching was observed in the sandy Gypsisol. Atrazine was leached only in the clay-rich Vertisol where the surfactants were present longer than in the plot with sandy Gypsisol.

ArticleTitle Field Assessment of Sludge Metal Bioavailability to Crops: Sludge Rate Response

Authors Logan, T.J.; B.J. Lindsay; L.E. Goins; J.A. Ryan

Journal Journal of Environmental Quality Vol 26: 534-550 (1997)

Abstract

ArticleTitle Assessment of free-living nitrogen fixation activity as a biological indicator of heavy metal toxicity in soil.

Authors Lorenz, S.E.; McGrath, S.P.; Giller, K.E.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. June 1992. v. 24 (6) p. 601-606.

Abstract The suitability of free-living N₂-fixing bacteria as biological indicators for heavy metal toxicity in soil was assessed. The sensitivity of potential N₂-fixation activity by cyanobacteria and aerobic heterotrophic bacteria were assessed using the acetylene reduction assay (ARA) on contaminated soils containing various concentrations of Zn, Cu, Ni, Cd, Cr and Pb. Soils from three long-term experiments (Woburn, Lee Valley, Luddington sites) were used which had previously been treated with metal-contaminated sewage sludge. A gradient of increasing heavy metal concentrations was made up by mixing uncontaminated and metal-contaminated Woburn soils. On the Woburn soils, concentrations of heavy metals in soil close to or below the current U.K. permissible limits (except for Cd which was greater than the limit) led to 94% inhibition of heterotrophic and up to 98% reduction of cyanobacterial N₂-fixation activity. Heterotrophic activity was also strongly inhibited in the Lee Valley soils. On the other soils, little or no N₂-fixation activity could be measured even in uncontaminated soils possibly due to low soil pH, the presence of mineralisable N in the soil, or absence of the microorganisms. Our results indicate that both methods are only of limited suitability for widespread use as biological indicators of metal toxicity. Assessment of heterotrophic N₂-fixation is more promising in this respect than measurement of cyanobacterial activity, as results are obtained more easily and quickly.

ArticleTitle Discharge of radioactive material into public sewers: the regulatory dilemma.

Authors Lue-Hing, Cecil

Journal Public Health Reports, v. 112 (July/Aug. '97) p. 317-18

Abstract Local sewage authorities face a regulatory dilemma over discharges of radioactive material into public sewers. The Nuclear Regulatory Commission (NRC) has sole regulatory control over discharges that contain radioactive material resulting from the handling, use, or processing of radioactive substances by a licensee of the NRC or the licensee of an agreement state. Local sewage agencies are thus in the unenviable position of being obliged to offer sewage treatment services to local NRC licensees without any clear enabling power of their own with regard to the discharge of radioactive wastewaters into the sewers. Moreover, the rule that empowers the NRC with the exclusive authority to regulate all aspects of health and safety issues regarding radioactive materials is inadequate to protect the interests of local sewage agencies. The EPA and the NRC are currently engaged in a cooperative research venture in an effort to correct or at least address this dilemma.

ArticleTitle Review of the Persistence of Nonylphenol and Nonylphenol Ethoxylates in Aquatic Environments

Authors Maguire, RJ

Journal Water Quality Research Journal of Canada, vol. 34, no. 1, pp. 37-78, 1999

Abstract Alkylphenol ethoxylates, in particular nonylphenol ethoxylates, are widely used nonionic surfactants that are discharged in high quantities to sewage treatment plants and directly to the environment in areas where there is no sewage or industrial waste treatment. This article reviews the treatability of nonylphenol ethoxylates and nonylphenol in sewage treatment plants and their persistence in aquatic environments. Nonylphenol ethoxylates can be biologically degraded in sewage treatment plants and in natural environments. Some of the degradation products, including nonylphenol, are more persistent than the parent surfactants and they are found in receiving waters of sewage treatment plants. Nonylphenol in particular is found at high concentrations in some sewage sludges that may be spread on agricultural lands. While some sewage treatment plants discharge significant amounts of nonylphenol ethoxylate degradation products in their final effluents and digested sludges compared to what enters the plant, others degrade nonylphenol ethoxylates more or less completely. The differences in treatment efficiency of such compounds and their degradation products among different sewage treatment plants have been attributed to the load of the surfactants in influent streams, plant design and operating conditions, and other factors such as temperature of treatment. The highest nonylphenol ethoxylate elimination rates were achieved in plants characterized by low sludge-loading rates and nitrifying conditions. In natural waters, it appears that parent nonylphenol ethoxylates are not persistent, but some degradation products may have moderate persistence, especially under anaerobic conditions. Recent results from mesocosm experiments indicate moderate persistence of nonylphenol in sediments, with half-lives of 28 to 104 days. Microbial acclimation to the chemicals is an important determinant of persistence vis-a-vis biodegradation. Sunlight photodegradation of such products is also likely important. Further research on the persistence in natural environments of the lower ethoxylate and carboxylate degradation products, as well as nonylphenol, is necessary. Based on the limited data available, nonylphenol and the lower ethoxylates and carboxylates are persistent in groundwater. They are also persistent in landfills under anaerobic conditions, but they do not appear to be persistent in soil under aerobic conditions. Recommendations are made for further research in order to more fully characterize the treatability of nonylphenol ethoxylates and their degradation products in sewage treatment plants and their persistence in the natural environment.

ArticleTitle Metal Trace Elements Brought on by fertilizers and biosolids spreading

Authors Maisonnave, V; M. Montrejaud-Vignoles; J.L. Lacout; C. Bonnin; C. Vignoles

Journal WEFTEC 99

Abstract

ArticleTitle Degradation of alkylphenol ethoxylates by *Pseudomonas* sp. strain TR01.

Authors Maki, H.; Masuda, N.; Fujiwara, .Y; Ike, M.; Fujita, M.

Journal Applied and Environmental Microbiology. 1994, 60: 7, 2265-2271; 34 ref.

Abstract An alkylphenol ethoxylate-degrading bacterium *Pseudomonas* str. TR01 was isolated from activated sludge of a municipal sewage treatment plant by enrichment culture. This str. had an opt. temp. and pH of 30°C and 7, resp., for both growth and the degradation of Triton N-101 (a nonylphenol ethoxylate in which the average number of ethylene oxide [EO] units is 9.5). The str. was unable to mineralize Triton N-101 but did degrade its EO chain exclusively. The resulting dominant intermediate was identified by normal-phase HPLC and GC-MS as a nonylphenol ethoxylate with 2 mol of EO units. A carboxylated metabolite, [(nonylphenoxy)ethoxy]acetic acid, was detected by GC-MS. This bacterium also metabolized alcohol ethoxylates with various numbers of EO units but not polyethylene glycols whatever their degree of polymerization. By oxygen consumption assay, the alkyl group or arene corresponding to the hydrophobic part of alcohol ethoxylates or alkylphenol ethoxylates was shown to contribute to the induction of the metabolic system of the EO chain of Triton N-101, instead of the EO chain itself, which corresponds to its hydrophilic part. Thus, the isolated pseudomonad bacterium has unique substrate assimilability: it metabolizes the EO chain only when the chain is linked to bulky hydrophobic groups.

ArticleTitle Radioactivity in municipal sewage and sludge

Authors Martin, JE; Fenner, FD

Journal Public Health Reports, 1997 , v 112 , n4 (Jul - Aug) , pp. 308-316, No of Ref: 18

Abstract Objective. To determine the environmental consequences of discharges of radioactivity from a large medical research facility into municipal sewage, specifically I-131 activity in sewage sludge, and the radiation exposures to workers and the public when sludges are incinerated. Methods. The authors measured radioactivity levels in the sludge at the Ann Arbor, Michigan, Waste Water Treatment Plant following radioiodine treatments of two patients at the University of Michigan hospital complex and performed a series of calculations to estimate potential radiation doses due to releases of I-131 from incineration of sewage sludge. Results. Approximately 1.1% of the radioactive I-131 administered therapeutically to patients was measured in the primary sludge. Radiation doses from incineration of sludge were calculated to be 0.048 millirem (mrem) for a worker during a period in which the incinerator filtration system failed, a condition that could be considered to represent maximum exposure conditions for two nine-hour days. Calculated results for a more typically exposed worker (with the filtration system in operation and a 22-week period of incineration) yielded a committed effective dose equivalent of 0.066 mrem. If a worker were exposed to both conditions during the period of incineration, the dose was calculated to be 0.11 mrem. For a member of the public, the committed effective dose equivalent was calculated as 0.003 mrem for a 22-week incineration period. Exposures to both workers and the public were a very small fraction of a typical annual dose (about 100 mrem excluding radon, or 300 mrem with radon) due to natural background radiation. Transport time to the treatment plant for radioiodine was found to be much longer than that of a normal sewage, possibly due to absorption of iodine by organic material in the sewer lines. The residence time of radioiodine in the sewer also appears to be longer than expected. Conclusion. I-131 in land-applied sludge presents few health concerns because sufficient decay occurs before it can reach the public; however, incineration, which is done in winter months, directly releases the I-131 from sewage sludge to the atmosphere, and even though exposures to both workers and the public were found to be considerably lower than 1% of natural background, incineration of sludge is a pathway for public exposure. Although I-131 was readily measurable in sewage sludge, only about 1% of the radioiodine administered to patients was found in the sludge. The fate of the remaining radioactivity has not been established; some may be in secondary and tertiary residuals, but it is quite likely that most passed through the plant and was discharged in dilute concentrations in plant emissions. The behavior of radioiodine and other radioactive materials released into municipal sewerage systems, such as those from large medical facilities, is not yet well understood.

ArticleTitle International Perspective

Authors Matthews, P.

Journal WEFTEC 99

Abstract The paper will provide a comparison of European and American biosolids management practices based on the latest thinking regarding sustainability. One interesting conclusion is that the gap between the EU and the US is not as big as has been assumed to date.

ArticleTitle Toxic metal accumulation from agricultural use of sludge: Are USEPA regulations protective?

Authors McBride M B

Journal Journal of Environmental Quality 24 (1): p 5-18 1995

Abstract The new USEPA regulations for the use of sewage sludges will permit concentrations of particular toxic metals to increase locally on agricultural land by a factor of a hundred or more above present soil concentrations. Short-term field experiments have shown that the adsorptive properties of sludges themselves often prevent excessive uptake of many of these metals into crops, a protection attributable largely to the added organic matter. This protection cannot be considered to be permanent or effective for all toxic metals, as indicated by data from old sludged sites. Differences in degree of protection are evident for greenhouse and field experiments, largely attributable to different rooting patterns and degree of sludge mixing in these two situations. The USEPA reliance on field data for metal uptake by corn (*Zea mays* L.) has led to an underestimation of phytotoxicity thresholds applicable to a wider range of crops, in part because corn is able to root deeply and is metal-tolerant. Also, the decision to use 50% yield reduction and plant top (rather than root) concentrations of heavy metals as phytotoxicity indicators may have obscured incipient toxicity. Long-term field observations (several decades) often show that sludge-applied metals can remain sufficiently available, even in nonacid soils when total metal concentrations are below the proposed EPA limits, to harm sensitive crops and microbes. It is concluded that the ultimate impact of toxic metals from sewage sludges at levels approaching the proposed USEPA limits on various soil-crop systems is potentially harmful.

ArticleTitle Growing food crops on sludge-amended soils: problems with the U.S. Environmental Protection Agency method of estimating toxic metal transfer.

Authors McBride, M.B.

Journal Environmental Toxicology and Chemistry. Pensacola, Fla. : SETAC Press. Nov 1998. v. 17 (11) p. 2274-2281.

Abstract The use of sewage sludges as farm fertilizers, encouraged in recent years by changes in U.S. Environmental Protection Agency (U.S. EPA) policy, has raised concerns among some scientists regarding food safety and long-term soil productivity. The U.S. EPA risk assessment for entry into the human diet of three of the most toxic metals, cadmium (Cd), mercury (Hg), and lead (Pb), utilized uptake coefficients (UCs) to calculate the amount of each metal that could enter food crops from the soil. Each UC was calculated as the increment of metal concentration in the edible part of the crop per unit increase of metal loading to the soil. However, the final UC estimates employed in the risk assessment are biased toward low values by a number of factors. These include the use of geometric means to obtain single-point averages of UCs for each crop group evaluated, rather than using arithmetic means or probabilistic methods, a systematic analytical or contamination error apparent in the reported metal concentrations of the control crops, and the fact that most of the UC values were derived for soils with pH 6 or higher. For more than 50% of all the soil and cropping conditions represented in the risk assessment, the geometrically averaged Cd UC values used by the U.S. EPA underestimated the actual risk posed by uptake into crops. The UC values for Pb and Hg are uncertain because of analytical or contamination errors, and because of the few data available for a number of crops. These uncertainties and biases in the risk assessment would advise a more cautious approach to agricultural and home garden use of sewage sludge than is permitted by the U.S. EPA 503 rule.

ArticleTitle Mobility and solubility of toxic metals and nutrients in soil fifteen years after sludge application

Authors McBride, MB; Richards, BK; Steenhuis, T; Russo, JJ; Sauve, S

Journal Soil Science, vol. 162, no. 8, pp. 487-500, Aug 1997

Abstract The increased use of sewage sludge as a fertilizer, combined with reports that large fractions of sludge-borne heavy metals cannot be accounted for several years after land application, indicates that more detailed study of potential mobility of these metals in soils is needed. A field site that had received a single heavy application of municipal sewage sludge was re-investigated 15 years later to measure the degree to which toxic heavy metals as well as nutrient elements remained in the topsoil. Total elemental composition of soil samples collected recently at this site was measured by inductively coupled plasma (ICP) spectrometry analysis of acid digests as well as by neutron activation analysis (NAA). These two methods gave comparable results for most sludge-applied heavy metals, but not for those elements that reside largely in mineral lattice structures resistant to acid digestion. Based on elemental deficits calculated using soil chromium concentration as an indicator of the original sludge concentration in the soil, it is estimated that most of the sludge-applied Na, S, Ca, and Sr, about 40% of the Zn and Cu, and less than 30% of the Cd and P have been lost from the topsoil. There is limited evidence that about half of other heavy metals such as Hg, Ag, and Au has also been lost. The ICP analysis of water extracts of the soils shows present concentrations of water-soluble Cu, Zn, and Ni in the sludge-amended topsoil are more than 10 times higher than those in the control soil. Ion-selective electrode measurements confirm that a large fraction of soluble Cu appears to be in an organically complexed and mobile form, which leaches to shallow groundwater. To varying degrees, numerous other elements, including Cd, P, and S, have solubilities substantially higher than in the control soil after the 15-year period. Nevertheless, despite the fact that the elemental deficits are correlated to the distribution coefficients of the elements, the deficits can only be accounted for by leaching if those elements were more soluble in the soil immediately after sludge application than they are now. The Zn and Cd remaining in the topsoil (pH 6.5-7.0) after 15 years is plant-available, as indicated by excess uptake and severe phytotoxicity symptoms in vegetable crops. In summary, although the vertical metal concentration profiles failed to manifest substantial movement of most trace metals, it appears that large fractions of certain metals applied in the sludge amendment have redistributed and moved out of the soil surface by physical-chemical or biological processes and that there is potential for groundwater and surface water contamination.

ArticleTitle Long-term effects of metals in sewage sludge on soils, microorganisms and plants.

Authors McGrath Steve P(a); Chaudri Amar M; Giller Ken E

Journal Journal of Industrial Microbiology 14 (2): p 94-104 1995

Abstract This paper reviews the evidence for impacts of metals on the growth of selected plants and on the effects of metals on soil microbial activity and soil fertility in the long-term. Less is known about adverse long-term effects of metals on soil microorganisms than on crop yields and metal uptake. This is not surprising, since the effects of metals added to soils in sewage sludge are difficult to assess, and few long-term experiments exist. Controlled field experiments with sewage sludges exist in the UK, Sweden, Germany and the USA and the data presented here are from these long-term field experiments only. Microbial activity and populations of cyanobacteria, *Rhizobium leguminosarum* bv. *trifolii*, mycorrhizae and the total microbial biomass have been adversely affected by metal concentrations which, in some cases, are below the European Community's maximum allowable concentration limits for metals in sludge-treated soils. For example, N-2-fixation by free living heterotrophic bacteria was found to be inhibited at soil metal concentrations of (mg kg⁻¹): 127 Zn, 37 Cu, 21 Ni, 3.4 Cd, 52 Cr and 71 Pb. N-2-fixation by free-living cyanobacteria was reduced by 50% at metal concentrations of (mg kg⁻¹): 114 Zn, 33 Cu, 17 Ni, 2.9 Cd, 80 Cr and 40 Pb. *Rhizobium leguminosarum* bv. *trifolii* numbers decreased by several orders of magnitude at soil metal concentrations of (mg kg⁻¹): 130-200 Zn, 27-48 Cu, 11-15 Ni, and 0.8-1.0 Cd. Soil texture and pH were found to influence the concentrations at which toxicity occurred to both microorganisms and plants. Higher pH, and increased contents of clay and organic carbon reduced metal toxicity considerably. The evidence suggests that adverse effects on soil microbial parameters were generally found at surprisingly modest concentrations of metals in soils. It is concluded that prevention of adverse effects on soil microbial processes and ultimately soil fertility, should be a factor which influences soil protection legislation.

ArticleTitle Assessment of the toxicity of metals in soils amended with sewage sludge using a chemical speciation technique and a lux-based biosensor.

Authors McGrath Steve P(a); Knight Bruce; Killham Ken; Preston Sara; Paton Graeme I

Journal Environmental Toxicology and Chemistry 18 (4): p 659-663 April, 1999

Abstract Currently, regulations regarding the maximum permitted concentrations of metals in soils are based on measurements of the total concentration. However, a range of chemical and biological techniques are being developed to predict the bioavailable component of these pollutants. A lux-based biosensor was tested in soil solutions extracted from two field experiments at Braunschweig, Germany, that had the same metal inputs, but differed in pH. The bioluminescence response was found to decline as the free Zn²⁺ increased, and both soils fitted the same relationship with soil solution metal concentrations. The EC₂₅ and EC₅₀ derived from this curve were 1.9 and 6.1 mg/L, respectively. In contrast, the response to total Zn concentrations in the bulk soil showed distinct curves for each soil, further highlighting the appropriateness of free Zn²⁺ as a toxicity indicator. Other metals were present in the soil, but were unlikely to be toxic, because the observed concentrations were less than their individual toxic threshold values in solution. Bioluminescence-based biosensors were concluded to possibly offer an inexpensive and rapid technique to evaluate the bioavailability of metals in soil systems. The response of these biosensors can be related to soil solution speciation measurements, and this gives a common basis for expression of toxic thresholds in different soils.

ArticleTitle Uptake and transfer of PCDD/Fs by cattle fed naturally contaminated feedstuffs and feed contaminated as a result of sewage sludge application: 1. Lactating cows.

Authors McLachlan M; Richter W

Journal Journal Of Agricultural And Food Chemistry; 46 (3). 1998. 1166-1172.

Abstract The uptake and transfer of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) was investigated in four Simmental cows with various lactation rates and body fat levels. During phase 1 a contaminant mass balance was conducted over 7 days using feed containing background levels of PCDD/Fs that were primarily of atmospheric origin. In phase 2 the same cows were fed grass silage from a field that had a history of repeated sewage sludge applications, and after 3 weeks a second mass balance was conducted over 7 days. The uptake of several of the PCDD/F congeners was up to 50 times higher during phase 2 than during phase 1. However, the transfer of these congeners to the milk was only 2 times lower than during phase 1. Taking into consideration the fact that the phase 2 mass balance was not conducted at steady state, it was concluded that the carry-over of PCDD/Fs entering the feed as a result of sewage sludge fertilization is not significantly different from that for feed containing background levels of PCDD/Fs of atmospheric origin.

ArticleTitle Uptake and transfer of PCDD/Fs by cattle fed naturally contaminated feedstuffs and feed contaminated as a result of sewage sludge application. 1. Lactating cows.

Authors McLachlan, M.; Richter, W.

Journal Journal of Agricultural and Food Chemistry. 1998, 46: 3, 1166-1172; 19 ref.

Abstract During 1994, the uptake and transfer of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) was investigated in 4 Simmental cows with various lactation rates and body fat levels at the metabolism station of the Bavarian Centre for Animal Husbandry. During phase 1, a contaminant mass balance was conducted over 7 days using feed containing background levels of PCDD/F that were of atmospheric origin. In phase 2, the same cows were fed grass silage from a field that had a history of repeated sewage sludge applications, and after 3 weeks a second mass balance was conducted over 7 days. The uptake of several of the PCDD/F congeners was about 50-times higher during phase 2 than during phase 1. However, the transfer of these congeners to milk was only about 2-times lower than during phase 1. Taking into consideration the fact that the phase 2 mass balance was not conducted at steady state, it is concluded that the carry-over of PCDD/F entering the feed as a result of sewage sludge fertilization is not significantly different from that for feed containing background levels of PCDD/F of atmospheric origin.

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- ArticleTitle** Persistence of PCDD/Fs in a sludge-amended soil
- Authors** McLachlan, Michael S.; Sewart, Andrew P.; Bacon, Jeffrey, Bacon R.; Jones, Kelvin C.
- Journal** Environmental Science and Technology v 30 n 8 Aug 1996. p 2567-2571 Publication Year: 1996
- Abstract** Data are presented on PCDD/F persistence in a sludge-amended soil sampled from a long-term field experiment started in 1968. Over 50% of the PCDD/Fs present in the soil in 1972 were still present in 1990. The concentrations of all congeners were observed to decrease gradually and in the same manner over this time, indicating that either physical loss of material from the experimental plot had occurred or all congeners had undergone a uniform reduction in extractability over time. Half-lives for the disappearance of PCDD/Fs from the sludge-amended plot post-1972 were of the order of 20 years; however, the degradation/alteration of PCDD/Fs in soil may take much longer since these half-lives are believed to be principally affected by physical removal.
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- ArticleTitle** Polychlorinated dibenzo-p-dioxins and dibenzofurans in sewage sludge: Sources and fate following sludge application to land
- Authors** McLachlan, MS; Horstmann, M; Hinkel, M
- Journal** Science of the Total Environment, Jun 1996, pp. 109-123, vol. 185, no. 1-3
- Abstract** Municipal sewage sludge is ubiquitously contaminated with polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F). Whereas in Germany there are some industrial sources, associated in particular with the use of pentachlorophenol (PCP) in the textile industry, surface runoff and household wastewater play a more important role in most treatment plants. Most of the higher chlorinated PCDD/F congeners in sludge originate in textiles which become contaminated during production through the use of PCP. The PCDD/F, which are contaminants in technical PCP, are washed out of textiles in the washing machine and enter household wastewater. The lower chlorinated PCDD/F, on the other hand, reach sludge largely as the result of transport of atmospheric deposition to the treatment plant in surface runoff. Following application of sewage sludge to land, the PCDD/F are very persistent, with half lives in excess of 10 years. They accumulate in soils and can under some conditions enter the agricultural food chain. The potential risk of land application of sewage sludge increasing human exposure to PCDD /F depends on the level of sludge contamination, the intensity of sludge use and the agricultural practices.
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- ArticleTitle** After effects of metals derived from a highly metal-polluted sludge on maize (*Zea mays* L.).
- Authors** Mench, M.J.; Martin, E.; Solda, P.
- Journal** Water air soil pollution. Dordrecht : Kluwer Academic Publishers. June 1994. v. 75 (3/4) p. 277-291.
- Abstract**

ArticleTitle The bioavailability of Cd and Zn from soils amended with sewage sludge to winter wheat and subsequently to the grain aphid *Sitobion avenae*

Authors Merrington, G; Winder, L; Green, I

Journal Science of the Total Environment, vol. 205, no. 2-3, pp. 245-254, Oct 1997

Abstract An agricultural soil in southern England was amended with a single application of sewage sludge from a municipal source at rates of 0, 5, 7.5, 10, 15 and 20 t ha super(-1) dry solids. Soil concentrations of Cd and Zn in the field plots ranged from 0.109 to 0.180 mg kg super(-1) and 26.3 to 34.3 mg kg super(-1), respectively, dependent on sewage sludge application rate. Concentrations of Cd and Zn in the shoots of winter wheat grown were dependent on the rate of sewage sludge application to the soil. Concentrations of Cd in the ears of wheat were not dependent on sewage sludge application rate, whilst Zn concentrations were dependent. Grain aphids (*Sitobion avenae*) collected from the host plants accumulated concentrations of Cd and Zn up to 0.386 mg Cd kg super(-1) and 319 mg kg super(-1) (eight and 10 times greater, respectively, than the concentrations on the ears on which they were feeding). Regression analysis demonstrated that the concentrations of Cd and Zn in *S. avenae* could be predicted from the concentrations of these metals in the soil. The retention characteristics of the sludge amended soils and control soils for Cd and Zn were assessed by batch adsorption experiments. From the sorption data it was observed that the sewage sludge amended soils showed no significant change in Cd affinity when compared to the control soils. However, for Zn, the reduction in the Freundlich distribution coefficient of the isotherms of the sludge treated soils were significant when compared to the control soils - indicating a reduced affinity for Zn at these relatively low sewage sludge application rates.

ArticleTitle Resistance patterns of *E. coli* strains isolated from domestic sewage before and after treatment in both aerobic lagoon and activated sludge.

Authors Mezrioui, N.; Baleux, B.

Journal Water Research-Oxford. 1994, 28: 11, 2399-2406; 30 ref.

Abstract Antibiotic resistance of 870 *Escherichia coli* strs isolated from aerobic lagoons and activated sludge plants in France was examined. The efficiency of both treatment systems in removing faecal coliforms was also studied. *E. coli* strs isolated from the lagoon effluent showed significantly greater antibiotic resistance than those isolated from domestic sewage. This was probably related to the selection of resistant strs by this type of treatment. Coliform reduction was greater in the lagoon system.

ArticleTitle The determination of radioisotope levels in municipal sewage sludge

Authors Miller, WH; Kunze, JF; Banerji, SK; Li, Yu-Chu; Graham, C; Stretch, D

Journal Health Physics, vol. 71, no. 3, pp. 286-289, 1996

Abstract Sludge samples from 25 municipal waste water treatment plants have been analyzed to determine the level of environmentally present, man-made, gamma-ray emitting radioisotopes. Samples were freeze dried and separated into dried sludge, liquid-soluble and liquid-insoluble components. These were counted in the low background level, whole body counter at Missouri University using a standard intrinsic-Germanium spectrometer. After freeze drying, the liquid effluents from the samples were not found to have statistically significant levels of radioactivity. Using log-normal analysis, the dried sludge was found to have 0.0016 plus or minus 0.0022 Bq g super(-1) (0.04 plus or minus 0.06 pCi g super(-1)) of super(137)Cs and 0.001 plus or minus 0.003 Bq g super(-1) (0.03 plus or minus 0.08 pCi g super(-1)) of super(60)Co. These data can be used to determine if sewage effluents from nuclear facilities have levels of radioactivity above that expected from the environment.

ArticleTitle Medicine cabinets in our water

Authors Montague, Peter

Journal Earth Island Journal , 1999 VOL. 14, NO. 1 (Winter-Spring) , 30, 1999

Abstract

ArticleTitle Transference of heavy metals from a calcareous soil amended with sewage-sludge compost to barley plants

Authors Moreno, JL; Garcia, C; Hernandez, T; Pascual, JA

Journal Bioresource Technology, vol. 55, no. 3, pp. 251-258, 1996

Abstract Barley plants were cultivated in a calcareous soil (pH 8.77) amended, at different rates, with sewage-sludge composts containing different heavy-metal contents and the transference of these heavy metals to the plant was studied. The addition to the soil of contaminated compost (mainly in Cd) at a high rate led to a decrease in grain yield but did not affect straw yield. Cadmium and Zn were easily absorbed by barley plants, increasing their concentration with respect to the control in plants grown in the soil amended with compost containing high amounts of these metals. However, Ni and particularly Cu were retained by organic matter and were not transferred to plants. Regardless of the compost heavy-metal contents, plants grown in amended soils showed higher N and P contents than control plants. The concentrations of Cd and Zn in soils were positively correlated with Cd and Zn contents in the plants, while no correlation was found between the concentrations of Cu or Ni in soil and plant. After cultivation, amended soils showed a better nutritional state than control soil (higher N-NO super(-) sub(3) and total- and available-P than the control).

ArticleTitle Heavy metal contaminants in inorganic and organic fertilizers.

Authors Mortvedt, J.J.

Journal Fertil-res. Dordrecht : Kluwer Academic Publishers. 1995/1996. v. 43 (1/3) p. 55-61.

Abstract Commercial phosphate (P) fertilizers contain small amounts of heavy-metal contaminants which were minor constituents in phosphate rock (PR). Animal manures and sewage sludges (biosolids) are the main organic fertilizers and the latter also may contain heavy-metal contaminants. Heavy metals in biosolids may be found in the inorganic form or may be organically complexed, which could affect their chemical reactions in soil. These heavy metals may accumulate in soil with repeated fertilizer applications. Cadmium (Cd) is the heavy metal of most concern because it may affect human health. Other heavy metals of possible significance are arsenic (As), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), and vanadium (V). Some countries have set tolerance limits on heavy-metal additions to soil because their long-term effects are unknown. These limits usually are set for the tillage layer (surface 20-30 cm) of soil where most root activity occurs. Controls on heavy-metal concentrations in sewage biosolids and their maximum total and annual loading rates to soil have been imposed in some countries. Regulations also have been proposed for phased-in limits on maximum heavy metal concentrations permitted in P fertilizers, or they are already in effect. Most of the fertilizer regulations relate Cd limits to P concentrations, so P application rates dictate Cd inputs to soil. Regulations affecting sewage biosolids include a number of heavy metals, while those concerning P fertilizers only include limits on Cd at this time.

ArticleTitle Health impact of polychlorinated dibenzo-p-dioxins: A critical review

Authors Mukerjee, D

Journal Journal of the Air & Waste Management Association, vol. 48, no. 2, pp. 157-165, Feb 1998

Abstract Polychlorinated dibenzo-p-dioxins (PCDDs), commonly known as dioxins, form as unwanted impurities in the manufacturing of chlorophenol and its derivatives - pulp and paper - and in the combustion of municipal, sewage-sludge, hospital, and hazardous waste. Combustion, in presence of a chlorine donor, seems to be a major source of these compounds. Extremely persistent and widely distributed in the environment, PCDDs have been detected in all three primary and many secondary media. Releases into the air occur mainly from combustor emissions. Atmospheric dispersion, deposition, and subsequent accumulation in the food chain seem to be the major pathways of exposure to the general population. Residues of these chemicals have been detected in soil, sediment, fish, meat, cow's milk, human adipose tissue, and mothers' milk. In general, these chemicals have high lipophilicity. The elimination half-life of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in humans is approximately 7-11 years. Very little human toxicity data from exposure to PCDDs are available. Dioxin exposures to humans are associated with increased risk of severe skin lesions such as chloracne and hyperpigmentation, altered liver function and lipid metabolism, general weakness associated with drastic weight loss, changes in activities of various liver enzymes, depression of the immune system, and endocrine- and nervous-system abnormalities. It is a potent teratogenic and fetotoxic chemical in animals. A very potent promoter in rat liver carcinogenesis, TCDD also causes cancers of the liver and other organs in animals.

ArticleTitle Occurrence and fate of phthalates in soil and plants.

Authors Muller, J.; Kordel, W.

Journal Science of the Total Environment. 1993, No.SUP-93, 431-437; from Proceedings of the 2nd European Conference on Ecotoxicology, May 11-15, 1992, Amsterdam, Netherlands; 12 ref.

Abstract Phthalate concentrations (di-(2-ethylhexyl)phthalate [DEHP], dibutyl phthalate [DBP] and butylbenzylphthalate) were measured near phthalate-emitting plants and in unpolluted areas in soil and maize. The differentiation between deposition and contamination via the soil-root pathway was emphasized. Plots were fertilized with phthalate-containing sewage sludge prior to the cultivation of maize, oats and potatoes. In another experiment plants were exposed to phthalate-treated dust. Degradation and uptake by plants of the three phthalates were studied. The results show that phthalates are general air contaminants and can also be found in unpolluted areas. The concentrations ranged from background levels to peak values of 490 mg/kg for DEHP and 560 mg/kg for DBP in soil and 20 ppm DBP in plants. Model experiments suggest that surface accumulation of phthalates in plants and transport of the substances into other parts of the plants was not detectable. Uptake of phthalates via the soil pathway was not detected, either. The results confirm that the accumulation of airborne phthalates in plant cuticles may be an important pathway, whereas the bioavailability of phthalates in soil and from leaves can be ignored.

ArticleTitle Symbiotic effectiveness of *Rhizobium trifolii* and mineralisation of legume nitrogen in response to past amendment of a soil with sewage sludge

Authors Munn K.J.; Evans J.; Chalk, P.M.; Morris, S.G.; Whatmuff, M.

Journal JOURNAL OF SUSTAINABLE AGRICULTURE , 1997 , v 11 , n1 , pp. 23-37

Abstract The effects of sewage sludge contaminated with heavy metals on the symbiotic effectiveness of *R. trifolii*, white clover N₂ fixation and N mineralisation were investigated in surface (0-10 cm) soil from a 10 year-old field experiment at Glenfield, NSW. The soil had been amended with nil, low (40 dry t ha⁻¹) or high (120 dry t ha⁻¹) rates of sludge, applied annually for 5 consecutive years to an unlimed (pH 4.6) and limed (pH 5.2) red podsollic soil. The total heavy metal content of the soil collected from the site 5 years after the last sludge application ranged (mg kg⁻¹ soil) 114-122 (nil sludge), 286-295 (low sludge) and 532-583 (high sludge). Air-dried soil was sieved (< 2 mm), then placed in pots which were sown to white clover and ryegrass, or to ryegrass only. The amount and proportion of clover N derived from air after 7 weeks growth in a glasshouse were determined using N-15 isotope dilution; and the intrinsic symbiotic effectiveness (ISE) of *R. trifolii* isolated from the clover nodules was estimated from the N yield of clover seedlings grown on N-free seedling agar inoculated with the isolates. Treatment effects on N mineralisation were determined from the concentrations of inorganic N released on soil incubation with or without incorporated lucerne. Amending soil with sludge did not reduce the ISE of *R. trifolii* in either unlimed or limed soil, the between-isolate variance in ISE, nor the proportion of clover N derived from air, as compared to unamended soil. The amount of N fixed by clover was increased in the sludged soils. The concentrations of inorganic N in the N mineralisation study were greater in the sludge amended soils and with incorporation of lucerne; and the differences in inorganic N between plus and minus lucerne incorporation were similar in both the sludged and unamended soils. The sludge rates and associated heavy metal loads historically imposed on this soil have not proven detrimental to N₂ fixation by *R. trifolii*, or to the net mineralisation of soil or incorporated organic N.

ArticleTitle Selective inhibitors of germination of legume seeds in activated sludge compost.

Authors Nagaoka, T.; Umezu, K.; Kouno, K.; Yoshida, S.; Ishiguro, Y.; Ando, T.

Journal Plant-growth-regul. Dordrecht : Kluwer Academic Publishers. Dec 1996. v. 20 (3) p. 295-302.

Abstract Water extracts of the compost produced from activated sludge and coffee residue were found to be selectively inhibitory to seed germination of some legumes. Germination rate of white clover (*Trifolium repens* L.), red clover (*Trifolium pratense* L.) and alfalfa (*Medicago sativa* L.) seeds were reduced to 2, 29 and 73% of the control, respectively, by water extracts of the compost (20 g l⁻¹). However, the extracts did not show any inhibition to seed germination of sorghum (*Sorghum bicolor* Moench), African millet (*Eleusine coracana* Gaertn.), and Komatsuna (*Brassica rapa* L.) at the same concentration. The inhibitors in the compost extracts were separated by ion-exchange chromatography and reverse-phase high performance liquid chromatography (HPLC) and the inhibitory activities of seed germination were tested with white-clover seeds. Five inhibitors were isolated and identified as 3,4-dichlorophenylacetic acid (3,4-DCP), 3,4-dichlorobenzoic acid (3,4-DCB), 3,4,5-trichlorophenylacetic acid, 3,4,5-trichlorobenzoic acid and mono-2-ethylhexylphthalate by ¹H-, ¹³C-NMR spectroscopy and mass spectrometry. The inhibitory activities of some authentic chemicals of the inhibitors and the related compounds were compared. The results indicated that the main inhibitor in the compost could be 3,4-DCB, which was contained at the concentration of 6.58 mg kg⁻¹ compost and showed the strongest inhibitory effect on seed germination of white clover among the tested compounds.

ArticleTitle Organic compounds in sludge-amended soils and their potential for uptake by crop plants.

Authors O'-Connor, G.A.; Jones, K. (ed.); Alcock, R

Journal Organic contaminants in sewage sludges. Proceedings of International Symposium, Lancaster University, UK, 16-17 May 1995. Science-of-the-Total-Environment. 1996, 185: 1-3, 71-81; 58 ref.

Abstract Several experimental techniques were used to measure toxic organic chemical (TO) plant uptake and to relate bioavailability to TO chemical and physical properties. The strengths and weaknesses of several experimental approaches are examined, and the resulting data evaluated. Sound experimental data, especially field data and/or data from studies with endogenously sludge-borne TOs, indicated negligible contamination of crop plants with TOs in sludge-amended soils. Assessing the potential for plant uptake of sludge-borne TOs involved determining: (a) which TOs were most likely present in biosolids and what their toxicities are; (b) what quantities of TOs are likely to be added to the growth media via biosolids application; (c) what effects various dissipation/dispersion reactions have on the potential bioavailability of TOs; and (d) what are the various mechanisms for plant uptake/metabolism of TOs.

ArticleTitle Dioxin in Biosolids

Authors O'Dette, R. G.

Journal WEFTEC 99 Water Environment Federation

Abstract

ArticleTitle Rhizobium leguminosarum bv. trifolii in soils amended with heavy metal contaminated sewage sludges.

Authors Obbard, J.P.; Sauerbeck, D.R.; Jones, K.C.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. Feb 1993. v. 25 (2) p. 227-231.

Abstract Soils from a well controlled field experiment were screened for the presence and number of cells of Rhizobium leguminosarum bv. trifolii capable of effectively nodulating the host plant, white clover (Trifolium repens). Soils had been amended with anaerobically-digested or undigested sewage sludge at rates of 0, 100 and 300 m³ ha⁻¹ yr⁻¹ on plots of differing pH since 1980 and up to the present. Applications of anaerobically-digested sludge included additions with or without heavy metal salts. Rhizobium were present in all of the treatments, apart from the most metal-contaminated treatment in the soil of lower pH, despite the absence of the host plant from the field sward. Lack of nodulation and nitrogen fixation (acetylene reduction activity) for T. repens growing in soils was, in some cases, probably caused by the high concentrations of extractable nitrate present as plants subsequently grown in N-free media were effectively nodulated. Important effects on the size of the effective rhizobial population were apparent in relation to the soil pH, sludge type and addition rates, and the concentration of heavy metals present.

ArticleTitle Atmospheric emissions and depositions of cadmium, lead, and zinc in Europe during the period 1955-1987.

Authors Olendrzynski, K.; Anderberg, S.; Bartnicki, J.; Pacyna, J.; Stigliani, W.

Journal Environmental-Reviews. 1996, 4: 4, 300-320; 25 ref.

Abstract This paper presents a preliminary estimate of atmospheric emissions of cadmium, lead, and zinc in Europe during the period 1955-1987. The emission data were used as input to the atmospheric transport model TRACE (trace toxic air concentrations in Europe) of the International Institute for Applied Systems Analysis, to compute cumulative deposition loads of heavy metals onto European soils during the investigated time period. The maxima of cumulative depositions computed with the TRACE model over the entire period were approximately 60 mg/m² for cadmium, 1450 mg/m² for lead, and 2600 mg/m² in the case of zinc. The results presented should be considered first-order approximations. Major uncertainties embedded in such calculations are discussed. Heavy metals enter the soils from atmospheric load and with the application of fertilizers and sewage sludge. Once in the soil the metals can be mobilized, leading to plant and groundwater contamination. This threat is particularly valid for heavily polluted regions in Central Europe. The results of this study can be applied in assessing environmental and health effects of heavy metals and, therefore, are important for scientists as well as policy makers.

ArticleTitle Toxic and priority organics in municipal sludge land treatment systems.

Authors Overcash, M.R.; Webber, J.B.; Tucker, W.P.

Journal NTIS, SPRINGFIELD, VA (USA) , 1986, 151 pp

Abstract The goal of the research reported herein was to begin a methodical investigation of organic priority pollutants applied to plant-soil systems at rates characteristic of municipal sludge land treatment. A single chemical was applied at rates of 0.1, 10, and 100-fold of the expected value received during an annual application of municipal sludge. The ¹⁴C-chemicals investigated were in the following groups: polynuclear aromatics, phthalic acid esters, and substituted aromatic compounds. None of the organic priority pollutants studied was entirely excluded from all plant species at the rates of soil application utilized. The ratio of vegetation fresh weight concentration of a chemical to the concentration loaded initially onto the soil (bioaccumulation) was most typically less than 0.01 and always less than 1.0. Of the crops studied (fescue, corn, soybeans, wheat), no vegetation type was routinely the species evidencing the highest uptake of the organic chemicals used. Plant uptake appears to be largely governed by the losses over time from the soil and the water solubility of a given chemical.

ArticleTitle Use of sewage sludge on park and recreational lands.

Authors Palazzo, A.J.; Iskandar, I.K.; Clapp, C.E. (ed.); Larson, W.E. (ed.); Dowdy, R.H.

Journal Sewage sludge: land utilization and the environment. Proceedings of a conference held in Bloomington, Minnesota, USA, 11-13 August 1993. 1994, 101-103; 10 ref.

Abstract The use and benefits of sewage sludge as a fertilizer for golf courses, parklands, roadside trees and turf, etc., are discussed. Some questions about possible health and environmental effects involving pathogens, odours and pollutants remain to be answered.

ArticleTitle Antibiotics (ivermectin, monensin) and endocrine environmental chemicals (nonylphenol, ethinylestradiol) in soils. > OT: Antibiotika (Ivermectin, Monensin) und endokrine Umweltchemikalien (Nonylphenol, Ethinylostradiol) im boden: Mogliche Auswirkungen von synthetischen Umweltchemikalien auf mikrobielle Eigenschaften eines landwirtschaftlich genutzten Bodens.

Authors Pfeiffer, C.; Emmerling, C.; Schroder, D.; Niemeyer, J.

Journal Umweltwissenschaften-und-Schadstoff-Forschung. 1998, 10: 3, 147-153; 43 ref.

Abstract The influence of 4 synthetic chemicals (ivermectin, monensin, nonylphenol and ethinylestradiol) on biomass and microbial activity was studied in a laboratory experiment using a typical Luvisol derived from loess. The polyether antibiotic monensin, the antiparasitic agent ivermectin and the two environmental chemicals with endocrine effects nonylphenol and ethinylestradiol were chosen because of their toxicity to different organisms and known biological activity. These agents may enter the soil together with sewage sludge or manure. Selected microbial methods showed significant effects on the microbial biomass and microbial activity during constant physical (15 °C, 50% water holding capacity) and chemical conditions (pH, Corg) 1, 14 and 42 days after contamination.

ArticleTitle Occurrence of airborne bacteria and pathogen indicators during land application of sewage sludge.

Authors Pillai, S.D.; Widmer, K.W.; Dowd, S.E.; Ricke, S.C.

Journal Applied Environmental Microbiology. Washington : American Society for Microbiology. Jan 1996. v. 62 (1) p. 296-299.

Abstract Glass impingers (AGI-30) were used at a commercial sludge application site to determine the levels of airborne bacteria and pathogen indicators. Even though heterotrophic bacteria averaged 10(5) CFU/m³, none of the sites showed the presence of Salmonella spp. or indicators such as fecal coliforms or coliphages. Indicators such as H₂S producers and pathogenic clostridia were present in locations having significant physical agitation of the sludge material. PCR-based ribotyping using the 16S-23S interspacer region is a promising method to identify the genetic relatedness and origins of airborne clostridia.

ArticleTitle Effect of anaerobic stabilization of sewage sludges on the survival of *Ascaris suum* under laboratory conditions.

Authors Plachy, P.; Placha, I.; Juris, P.

Journal Helminthologia. 1997, 34: 4, 229-234; 21 ref.

Abstract Survival of *Ascaris suum* eggs was studied during anaerobic stabilization of sewage sludges in the laboratory at mesophilic and thermophilic temperature ranges. The effect of 20- and 30-day sludge hydraulic retention times (HRT) was also followed with mesophilic stabilization. Mesophilic anaerobic stabilization at 36°C with the 20-day HRT showed a mean of 76.8% and with the 30-day HRT 76.2% of viable eggs ($P < 0.01$). A mean of 94% of viable eggs was detected in the control after 30 days. Analysis of the effects of physico-chemical parameters during stabilization on egg survival showed no relationship between the percentage of viable eggs in fermentors with the 20-day HRT and pH, and in fermentors with the 30-day HRT with pH and the concentration of volatile fatty acids. Anaerobic thermophilic stabilization at 54°C reduced the proportion of viable non-embryonated *A. suum* eggs from 82.4 to 9% in 10 minutes. After 10 minutes of stabilization, all the eggs were eliminated.

ArticleTitle Detection of radionuclides in sewage water and sludge

Authors Puhakainen, M

Journal Radiochemistry, 1998 , v 40 , n6 (Nov-Dec) , pp. 529-533, No. Ref: 6

Abstract At wastewater treatment plants in Finland, radionuclides of various origins were detected in the sludge: those originating from medical use, nuclear weapons tests, the Chernobyl accident, and Finnish NPPs. In 1997, the activity of Cs-137 in the sludge varied from 24 to 47 Bq kg⁻¹ and that of I-131, from 108 to 250 Bq kg⁻¹ dry weight. The highest activity in sewage sludge and water was caused by medical use of I-131. The highest activity of I-131 detected in crude sewage was 94 000 Bq m⁻³. Only a minor portion of the I-131 passes into the sludge. Among other radionuclides used in medicine, Cr-51, Co-57, Fe-59, In-111 and Tl-201, Tl-202 were also detected in the sludge. Radionuclides apparently originating from the Finnish NPPs were detected in sludge from wastewater treatment plants in communities near the power plants: in Loviisa in the vicinity of the Loviisa NPP with 2 pressurized water reactors, Cr-51, Mn-54, Co-58, Fe-59, Co-60, Ag-110m, and Sb-124; in Rauma in the vicinity of the Olkiluoto NPP with 2 boiling water reactors, Mn-54, Co-58 and Co-60.

ArticleTitle Wastewater Sludge Disposal

Authors Radtke, Timothy M.; Gist, Ginger L.

Journal Journal of Environmental Health, v52, n2, p102(4), Sep-Oct 89

Abstract Bacteria were isolated from sludge samples collected in a Tennessee wastewater treatment plant and tested for antibiotic resistance and R-plasmid transfer. Of the 84 bacteria isolated, almost 62% were resistant to at least one of the 11 antibiotics tested, while 46.4% were resistant to two or more antibiotics. The ability to transfer resistance varied in the 50-72.2% range. Further assessment of antibiotic-resistant bacteria in wastewater treatment plant sludge is needed before disposing of sludge on land.

ArticleTitle Wastewater sludge disposal: antibiotic resistant bacteria may pose health hazard.

Authors Radtke, Timothy M; Gist, Ginger L

Journal Journal of Environmental Health, v. 52 (Sept./Oct. '89) p. 102-5

Abstract

ArticleTitle Bioaccumulation and toxicity of silver compounds: A review

Authors Ratte, H.T.

Journal Environmental Toxicology and Chemistry, vol. 18, no. 1, pp. 89-108, Jan 1999

Abstract A review of the literature revealed that bioaccumulation of silver in soil is rather low, even if the soil is amended with silver-containing sewage sludge. Plants grown on tailings of silver mines were found to have silver primarily in the root systems. In marine and freshwater systems, the highest reported bioconcentration factors (BCFs) were observed in algae (>10 super(5)), probably because of adsorption of the dissolved silver (<0.45 mu m fraction) to the cell surface. In herbivorous organisms (e.g., zooplankton and bivalves), the BCF was lower by about two orders of magnitude. Low amounts of silver were assimilated from food with no substantial biomagnification. In carnivores (e.g., fish), the BCF was also lower by one order of magnitude with no indication of biomagnification. Toxicity of silver occurs mainly in the aqueous phase and depends on the concentration of active, free Ag super(+) ions. Accordingly, many processes and water characteristics reduce silver toxicity by stopping the formation of free Ag super(+), binding Ag super(+), or preventing binding of Ag super(+) to the reactive surfaces of organisms. The solubility of a silver compound, and the presence of complexing agents (e.g., thiosulfate or chloride), dissolved organic carbon, and competing ions are important. In soil, sewage sludge, and sediments, in which silver sulfide predominates, the toxicity of silver, even at high total concentrations, is very low. The highly soluble silver thiosulfate complex has low toxicity, which can be attributed to the silver complexed by thiosulfate. Silver nitrate is one of the most toxic silver compounds. The toxic potential of silver chloride complexes in seawater is and will be an important issue for investigation. Aquatic chronic tests, long-term tests, and tests including sensitive life stages show lower toxicity thresholds (similar to 1 mu g Ag super+)/L). The organisms viewed as most sensitive to silver are small aquatic invertebrates, particularly embryonic and larval stages.

ArticleTitle Applicability of a yeast oestrogen screen for the detection of oestrogen-like activities in environmental samples

Authors Rehmann, K; Schramm, KW; Kettrup AA

Journal Chemosphere, 1999 , v 38 , n14 (Jun) , p 3303-3312, No. Ref: 23

Abstract A (xeno)oestrogen bioassay was introduced, using a genetically modified yeast strain which produces a fusion protein encompassing the human oestrogen receptor hormone binding domain and the yeast GAL4-DNA binding domain. Upon binding of appropriate substances this fusion protein recognises the respective DNA sequence thereby enhancing the transcription of a beta-galactosidase reporter gene. The bioassay procedure was evaluated by screening 30 compounds, including some known or suspected (xeno)oestrogens and determining EC50-values for 17 beta-oestradiol, 1.5 nM, 4-tert.-octylphenol, 6.7 mu M and bisphenol A, 104 mu M. Toluene extracts from different environmental matrices were tested for their oestrogenic activity. The positive test results obtained with a sewage sludge extract indicated the applicability of this bioassay for environmental monitoring.

ArticleTitle Sources, behaviour and fate of organic contaminants during sewage treatment and in sewage sludges

Authors Rogers, H R; Jones, K, ed; Alcock, R, ed

Journal Science of the Total Environment, 1996 , 185 (1-3) 3-26 No. of Refs.: 141 ref.

Abstract Recent concern over the environmental impact of sewage sludge application to agricultural land has drawn particular attention to the wide range of organic contaminants that may enter sewage treatment processes and persist in biosolids for disposal. This paper discusses processes influencing the fate and behaviour of organic contaminants during wastewater treatment and reviews literature relating to specific contaminants identified in sewage sludge. The difficulties associated with the development of specific methods for the analysis of trace residues of organic contaminants in complex matrices such as sludge are discussed. Some potential issues relating to impact of sewage sludge disposed to agricultural land are also considered.

ArticleTitle Sources, behaviour and fate of organic contaminants during sewage treatment and in sewage sludges

Authors Rogers, H.R.; Jones, K. (ed.); Alcock, R.

Journal Science of the Total Environment, Jun 1996, pp. 3-26, vol. 185, no. 1-3. Organic contaminants in sewage sludges. Proceedings of International Symposium, Lancaster University, UK, 16-17 May 1995.

Abstract The processes influencing the fate and behaviour of organic contaminants during waste water treatment are discussed and the literature relating to specific contaminants identified in sewage sludge is reviewed. The difficulties associated with the development of specific methods for the analysis of trace residues of organic contaminants in complex matrices such as sludge are discussed. Some potential issues relating to the impact of sewage sludge disposed to agricultural land are also considered.

ArticleTitle Sources, Behaviour and Fate of Organic Contaminants During Sewage Treatment and in Sewage Sludges

Authors Rogers, Howard R.

Journal Science of the Total Environment, v185, n1-3, p3(24), Jun 21, 96

Abstract An overview is presented of the current information on the occurrence of organic contaminants in sewage sludge and their fate during sewage-treatment processes. Data gleaned from the literature are presented in the areas of: organic chemistry; prioritization of contaminant residues; chemical fate during treatment, including sorption, chemical degradation, biodegradation, and volatilization; analytical aspects of analysis, such as sample storage, pre-extraction treatment, extraction, and clean-up procedures; and the occurrence of specific organic contaminants, including organochlorine pesticides, PCBs, chlorophenols, chlorophenoxy acids, organophosphorus compounds, nitrosamines, nitroaromatics, mineral oils, alkylphenols, lipids, acrylamide monomer, phthalate esters, organotin compounds, surfactants, chlorobenzenes, PCDDs, PCDFs, PAHs, and pharmaceutical chemicals.

ArticleTitle Issues of risk assessment and its utility in development of soil standards: the 503 methodology an example.

Authors Ryan, J. A.; Chaney, R. L.

Journal Contaminated soils: 3rd International Conference on the Biogeochemistry of Trace Elements, Paris, France, 15-19 May, 1995. p.393-413

Abstract A risk assessment for land application of sewage sludge was required in the development of the US Clean Water Act Section 503 Rule. The methodology reflects logical pathway analysis of transfer of pollutants to soils, plants, animals, and humans. As an example of the methodology a detailed analysis of human health effects from Cd is illustrated. All pathways for the sludge-applied Cd to be transferred to humans, and all processes in soils, plants, livestock, and humans were considered. Using appropriate data from field experiments, the transfer of soil Cd to diets of individuals who might grow a high fraction of the garden vegetables and fruits they consume for their lifetime was modelled. The model estimated that garden soils could reach 60 mg Cd/kg before Highly Exposed Individuals (those who grow 59% of fruits and vegetables and 37% of potatoes they consume for 50 years on a garden containing the maximum allowable cumulative application) would consume a lifetime average of 70 micro g Cd/day (the recommended maximum daily intake of Cd). Many sources of protection from Cd risk were identified, illustrating the hidden protection within even this analysis. Experimental evidence indicates that no individual would be harmed even if sludge amended soils reached 60 mg Cd/kg. However, because soil Cd has caused human disease, and because pretreatment can restrict sludge Cd to at least as low as 10-20 mg/kg unrelated to risk, it is considered prudent public policy to restrict utilization of sludges with Cd over these levels. 39 ref.

ArticleTitle Aerobic biodegradability of surfactants at low concentrations using an automated pressure transducer system.

Authors Salanitro, J.P.; Diaz, L.A.; Kravetz, L.

Journal Chemosphere. 1995, 31: 3, 2827-2837; 10 ref.

Abstract A simple and reliable automated pressure transducer system (APTS) to evaluate the ready and ultimate aerobic biodegradability of surfactants in 28 d at low concn (5 mg C/litre) using modifications of existing CO₂ evolution assays was developed. Pressure transducers (PT) were fitted to Gledhill-type flasks containing Sturm minerals solution, dilute (50 mg/litre) unacclimated activated sludge microbial seed and test compound. PT monitored microbial respiration through oxygen consumption from the headspace and CO₂ from metabolism was absorbed in a 1 M KOH solution within the flask. Results with nonionic ethoxylate (AE-7) and anionic sulfate (AS) surfactants prepared from linear or 2-alkyl branched C14-15 alcohol moieties showed that sewage bacteria readily consumed O₂ (70-140% ThO₂) and degraded these compounds to CO₂ (65-75% ThCO₂) in 12 d at 25C. However, when a more branched alcohol ethoxylate (NPE-9) was tested in the APTS, only 50% of both the ThO₂ was consumed and ThCO₂ was produced. Glucose and benzoic acid were biodegraded to CO₂ similarly to the AE-7 and AS surfactants. Comparison of alcohol ethoxylate degradation data in the APTS with those published from traditional Sturm test methods demonstrated that the CO₂ recovery results were the same for readily metabolized compounds.

ArticleTitle Influence of sewage sludge application on soil quality: II. Heavy metals.

Authors Samaras, V.; Tsadilas, C. D.

Journal Proceedings of the Fourth International Conference of Precision Agriculture, St. Paul, Minnesota, USA 19-22 July, 1998. Part A and Part B..

Abstract The influence of sewage sludge application on the total and available forms of Zn, Mn, Cu, Fe, Pb, Cd, and Ni was studied in a 2-year field experiment in Greece. The soil was a Typic Xerochrept cultivated with cotton after amendment with sewage sludge rates ranging from 0 to 30 t ha⁻¹ year⁻¹. The experimental design was completely randomized blocks with five treatments each replicated four times. After 2 years of sewage sludge application, soil samples were taken from all the plots from a depth 0 to 50 cm and the concentrations of the total and available forms (DTPA extractable) of the above-mentioned heavy metals were determined. The results showed that sewage sludge application significantly increased the total concentration of Cu, Zn, and Pb in the surface layer. DTPA extractable forms were increased significantly in all the metals studied except Mn. Total concentration of Cu, Zn, and Cd were strongly correlated with organic matter content. DTPA extractable Cu, Zn, Cd, and Fe were also strongly correlated with organic matter content positively and negatively with soil pH. For all the metals studied except Cu and Fe, there was no evidence of leaching in the deeper layers.

ArticleTitle Influence of the application of sewage sludges on soil microbial activity

Authors Sastre, I.; Vicente, M.A.; Lobo, M.C.

Journal Bioresource Technology (United Kingdom) 1996 , 57/1 (19-23)

Abstract Microbial populations and enzyme activities in a soil amended with sewage sludge in a long-term field experiment were studied in relation to the decomposition of organic matter. Two kinds of sewage sludges were applied to the soil at rates of 50 and 100 tons/ha/ year for 8 years. The percentage of humic acids increased in the soil with the application of sewage sludges. The enzyme activities exhibited a high correlation coefficient with the number of microorganisms and the content of humic substances. The results suggested that the sewage-sludge application increased microbial activity in the soil, contributing to the gradual decomposition of organic matter.

ArticleTitle Influence of the application of sewage sludges on soil microbial activity.

Authors Sastre, I; Vicente, M.A.; Lobo, M.C.(a)

Journal Bioresource Technology 57 (1): p 19-23 1996

Abstract Microbial populations and enzyme activities in a soil amended with sewage sludge in a long-term field experiment were studied in relation to the decomposition of organic matter. Two kinds of sewage sludges were applied to the soil at rates of 50 and 100 tons/ha/year for 8 years. The percentage of humic acids increased in the soil with the application of sewage sludges. The enzyme activities exhibited a high correlation coefficient with the number of microorganisms and the content of humic substances. The results suggested that the sewage-sludge application increased microbial activity in the soil, contributing to the gradual decomposition organic matter.

ArticleTitle Hepatitis A and occupational risk with sewage exposure.

Authors Schlosser, O; Roudot-Thoraval, F

Journal Revue Des Sciences De L'Eau/Journal of Water Science, vol. 8, no. 2, pp. 277-287, 1995

Abstract The availability of a first hepatitis A vaccine in 1992 raised the possibility of its use for workers exposed to sewage or sludge. This occupational risk was suspected because of the excretion of hepatitis A virus (HAV) in stools, and its resulting presence in sewage, because of the resistance of HAV to environmental stresses, and because of the documented wastewater-mediated transmission of HAV in the general population. On the other hand, the decreased diffusion of HAV in industrialized countries probably results in a less contamination of sewage. The aim of this study was to evaluate the possible risk of HAV infection from sewage exposure, which could lead to recommendations for vaccination for exposed workers. Methods: in a large private company involved in water supply, anti HAV IgG were sought in sera from workers in contact with sewage and from workers non exposed to sewage. Subjects were individually matched for age and education level. Cases included workers involved with the wastewater collection network, workers who monitor drinking water distribution networks in Paris (located in sewer mains in Paris), personnel of a large research laboratory involved with wastewater and sludge, as well as a few workers involved with drinking water production who may be frequently exposed to raw Seine river, Marne river or Oise river water (that could be contaminated with sewage). Histories of jaundice, travels to areas of endemic incidence of hepatitis A, and the duration of occupational exposure were noted. Anti-HAV IgG was measured in serum by an enzyme-linked immunosorbent assay (ELISA) method. These results emphasize the role of occupational exposure to sewage in HAV infection. Exposed workers should be vaccinated because of the frequency of the symptomatic form of hepatitis A in adults with severe and relapsing cases. The strategy of vaccination should take into account the high cost of the vaccine and the epidemiological situation of HAV in the country.

ArticleTitle Understanding phytotoxicity thresholds for trace elements in land-applied sewage sludge

Authors Schmidt, J.P.

Journal Journal of Environmental Quality, vol. 26, no. 1, pp. 4-10, Feb 1997

Abstract Sewage sludge contains trace elements. With repeated sludge applications as crop fertilizer, these trace elements may accumulate in the soil to phytotoxic concentrations. My objective was to assess the scientific basis for the current cumulative loading limits for Cu, Ni, and Zn in land-applied sewage sludge. An overview of the USEPA's phytotoxicity risk assessment, the basis for these loading limits, was presented, discussed, and compared in the context of the underlying principles of phytotoxicity thresholds. I concluded that EPA phytotoxicity thresholds in immature plants were arbitrarily selected, and extrapolations to field applications of sewage sludge were not substantiated. Variability in plant accumulation rates and soil sorption capacities of trace elements were not adequately considered in the EPA analysis. Because of the assumptions, simplifications, and extrapolations introduced into the phytotoxicity analysis, the final results, that is, EPA's cumulative loading limits for Cu, Ni, and Zn, are not substantiated by the analysis. The phytotoxicity analysis does not represent an appropriate application of underlying scientific principles. A more appropriate basis for regulating trace element applications in sewage sludge would reflect an understanding of site-specific characteristics, possibly including concentration limits for trace elements in plant tissue, soil, and/or groundwater. Additional research would be required to substantiate EPA's conclusions about the cumulative pollutant loading limits, as derived from EPA's phytotoxicity risk assessment.

ArticleTitle Organic contaminants in sewage sludge and their ecotoxicological significance in the agricultural utilization of sewage sludge.

Authors Schnaak, W.; Kuchler, T.; Kujawa, M.; Henschel, K.P.; Sussenbach, D.; Donau, R.; Herrchen, M. (ed.); Kordel-W (ed.); Scheunert-I

Journal Experimental and theoretical approaches in environmental chemistry. Chemosphere. 1997, 35: 1-2, 5-11; 5 ref.

Abstract The screening of sewage-sludge for organic pollutants was carried out in the state of Brandenburg, Germany. Samples were taken both in summer and winter. The waste water treatment plants were classified in three groups depending on the types of sewage treated (domestic, municipal and industrial waste water). The content of polychlorinated terphenyls, naphthalenes, chloropesticides, halogenated hydrocarbon solvents, aromatic hydrocarbon solvents (BTEX), chlorobenzenes, polyaromatic hydrocarbons, phenols, chlorophenols, phthalates, petroleum hydrocarbons, surfactants, organotin compounds and 2,4-dichloroaniline was estimated. Data from terrestrial ecotoxicology were used to estimate tolerable levels of soil contamination. This yields the so-called 'standard values' for concentrations of organic pollutants in sewage sludge. The concentrations of most pollutants in sewage sludge were below the standard value. However, surfactant and toluene concentrations exceeded the standard value.

ArticleTitle Effect of concentration and environmental form of tetradecenyl succinic acid on its mineralization in soil

Authors Schowanek, D.R.; Feijtel, T.C.J.; Federle, T.W.

Journal Biodegradation, vol. 7, no. 5, pp. 377-382, 1997

Abstract Tetradecenyl succinic acid (TSA) is the major component of a detergent builder (C12-C14 alkenyl succinic acid), which is inherently biodegradable. super(14)C-TSA was dosed as a component of sewage sludge into a soil with a history of sludge amendment at final added concentrations of 1.5 and 30 mg (kg soil) super(-1). In addition, it was dosed to the soil in an aqueous solution to a final added concentration of 30 mg (kg soil) super(-1). Dose and form were found to have a pronounced effect on the mineralization kinetics. When dosed in a realistic form and concentration (i.e. 1.5 mg (kg soil) super(-1) as a component of sludge), TSA was mineralized at its highest rate and to its greatest extent, and the mineralization half-life was 2.4 days. When dosed at 30 mg (kg soil) super(-1) as a component of sludge, mineralization began immediately, and the half-life was 23 days. In contrast, when dosed at this concentration in aqueous solution, the onset of mineralization was preceded by a 13 day lag period and the mineralization half-life was 69 days. Primary biodegradation and mineralization rates of TSA were very similar. Approximately, half the radioactivity was evolved as super(14)CO sub(2), while the remaining radioactivity became non-extractable, having presumably been incorporated into biomass or natural soil organic matter (humics). This study demonstrated that TSA is effectively removed from sludge-amended soils as a result of biodegradation. Furthermore, it showed the effect that dose form and concentration have on the biodegradation kinetics and the importance of dosing a chemical not only at a relevant concentration but also in the environmental form in which it enters the soil environment.

ArticleTitle INFLUENCE OF SOIL SAMPLING TECHNIQUES ON THE RESULTS OF HEAVY-METAL TRANSPORT INTO THE SUBSOILS AFTER LONG-TERM APPLICATION OF SEWAGE-SLUDGE

Authors Schulz,R.; Breuer, J; Romheld, V.; Marschner, H.

Journal AGRIBIOLOGICAL RESEARCH-ZEITSCHRIFT FUR AGRARBIOLOGIE AGRIKULTURCHEMIE OKOLOGIE , 1996 , V 49 , N2-3 , P 113-119

Abstract In a long-term field experiment with application of sewage sludge on a loess derived Luvisol samples from the subsoil (30 cm to 60 cm) taken with a 1-partite "PORKHAUER" auger had higher total contents of Cd, Zn and Pb than samples taken with a 3-partite "Nmin" sampler. The higher heavy metal contents in the subsoil samples taken with the "PURKHAUER" auger are obviously due to contamination of the subsoil samples by topsoil and thus overestimate the transport of heavy metals in the soil profile. After longterm application of sewage sludge the actual transport of dissolved Cd into the subsoil of the Luvisol is probably not higher than 10 g to 20 g ha(-1) a(-1).

ArticleTitle Long-term monitoring of soil gas fluxes with closed chambers using automated and manual systems.

Authors Scott, A.; Crichton, I.; Ball, B. C.

Journal Journal of Environmental Quality vol. 28 (5): p.1637-1643, 1999, 35 ref.

Abstract Two gas sample collection techniques, each of which is used in conjunction with custom made automated or manually operated closed chambers, are described. The automated system allows automatic collection of gas samples for simultaneous analysis of multiple trace gas efflux from soils, permitting long-term monitoring. Since the manual system is cheaper to produce, it can be replicated more than the automated and used to estimate spatial variability of soil fluxes. The automated chamber covers a soil area of 0.5 m² and has a motor driven lid that remains operational throughout a range of weather conditions. Both systems use gas-tight containers of robust metal construction, which give good sample retention, thereby allowing long-term storage and convenience of transport from remote locations. The containers in the automated system are filled by pumping gas from the closed chamber via a multiway rotary valve. Stored samples from both systems are analysed simultaneously for N₂O and CO₂ using automated injection into laboratory-based gas chromatographs. The use of both collection systems is illustrated by results from a field experiment on sewage sludge disposal to land where N₂O fluxes were high. The automated gas sampling system permitted quantification of the marked temporal variability of concurrent N₂O and CO₂ fluxes and allowed improved estimation of cumulative fluxes. The automated measurement approach yielded higher estimates of cumulative flux because integration of manual point-in-time observations missed a number of transient high-flux events.

ArticleTitle Trace element inputs into soils by anthropogenic activities and implications for human health

Authors Senesi, G.S.; Baldassarre, G.; Senesi, N.; Radina, B

Journal MATTER AND ENERGY FLUXES IN THE ANTHROPOCENTRIC ENVIRONMENT, Elsevier Science Ltd., Pergamon, P.O. Box 800, Jul 1999, pp. 343-377, Chemosphere, vol. 39, no. 2

Abstract Trace element definition and functions, and inputs into soils from the most important anthropogenic sources, related and not related to agricultural practices, of general and local or incidental concern, are discussed in the first part of this review. Trace element inputs include those from commercial fertilizers, liming materials and agrochemicals, sewage sludges and other wastes used as soil amendments, irrigation waters, and atmospheric depositions from urban, industrial, and other sources. In the second part of the review, the most important ascertained effects of soil trace elements on human health are presented. The possible relations found between some specific soil trace elements, such as Cd, Se, As and others, and cancer incidence and mortality, and diffusion of other important human diseases are reviewed. Brief conclusions and recommendations conclude this review.

ArticleTitle Review of the Aquatic Toxicity, Estrogenic Responses and Bioaccumulation of Alkylphenols and Alkylphenol Polyethoxylates

Authors Servos, M.R.

Journal Water Quality Research Journal of Canada, vol. 34, no. 1, pp. 123-177, 1999

Abstract A review of the available information on the toxicity and bioaccumulation of alkylphenols (AP) and their polyethoxylates (APE) and polyethoxycarboxylates (APEC) was conducted in support of their assessment as Priority Substances under the Canadian Environmental Protection Act. This included an examination of the acute and chronic toxicity of these compounds in a wide variety of aquatic organisms as well as an examination of their potential effects on endocrine function in fish and aquatic invertebrates. Although the data in the literature are scattered among many species, different test methods and chemicals, there is a consistent pattern in the toxicity. Nonylphenol (NP) and octylphenol (OP) are both acutely toxic to fish (17-3000 µg/L), invertebrates (20-3000 µg/L) and algae (27-2500 µg/L). In chronic toxicity tests no observable effect concentrations (NOEC) are as low as 6 mg/L in fish and 3.7 µg/L in invertebrates. There is an increase in the toxicity of both NPEs and OPEs with decreasing EO chain length. NPECs and OPECs are less toxic than corresponding APEs and have acute toxicities similar to APEs with 6-9 EO units. APs and APEs bind to the estrogen receptor resulting in the expression of several responses both in vitro and in vivo, including the induction of vitellogenin. The threshold for vitellogenin induction in fish is 10 µg/L for NP and 3 µg/L for OP. APEs also affect the growth of testes, alter normal steroid metabolism, disrupt smoltification and cause intersex (ova-testes) in fish. The available literature suggests that the ability of AP and APEs to bioaccumulate in aquatic biota in the environment is low to moderate. BCFs and BAFs in biota, including algae, plant, invertebrates and fish range from 0.9 to 3400. Although there are relatively few data available for OP or OPEs, their potential to bioaccumulate is expected to be similar to that of corresponding NP and NPEs.

ArticleTitle PCDD/Fs and non-o-PCBs in digested U.K. sewage sludges.

Authors Sewart, A.; Harrad, S.J.; McLachlan, M.S.; McGrath, S.P.; Jones, K.C.

Journal Chemosphere. Oxford : Pergamon Press. Jan 1995. v. 30 (1) p. 51-67.

Abstract

ArticleTitle Factors affecting nitrate leaching from sewage sludges applied to a sandy soil in arable agriculture.

Authors Shepherd, M.A.

Journal Agriculture Ecosystems & Environment 58 (2-3): p 171-185 1996

Abstract Application of sewage sludge to agricultural land is an increasingly popular disposal route and can be a valuable source of nitrogen (N) for crops. However, inappropriate application times or rates may lead to poor utilisation by crops and, thus, to nitrate leaching and contamination of water supplies. The effects on nitrate leaching of sludge type (raw liquid, digested liquid or dewatered digested cake), application time (September, November or January), application method (injected or surface-applied) and winter versus spring barley, were measured in annual field experiments on a sandy soil in 1991/1992 and 1992/1993 in central England. A second experiment tested the effects of a nitrification inhibitor (dicyandiamide; DCD) mixed with liquid digested sludge (1992/1993). Similar trends were found in both years, but leaching losses were larger in the first year, despite more rainfall in the second winter. It may have been that N was lost by alternative routes, particularly denitrification, in the second, wetter winter. The earlier the application in autumn, the greater was the N leaching. Liquid digested sludge, with a large proportion of its N content in ammoniacal form, presented the greatest leaching risk; losses were much smaller from raw liquid or dewatered cake. Losses were further exacerbated by deep injection of sludge. Drilling winter barley immediately after sludge applications in September decreased leaching only slightly compared with leaving the land bare during winter. The experiments suggest that autumn application of digested sludge to light textured arable land is inadvisable. Nitrification inhibitor shows some promise for decreasing leaching losses.

ArticleTitle Assessing soil quality for environmental purposes: Roles and challenges for soil scientists

Authors Sims, J.T.; Cunningham, S.D.; Sumner, M.E.

Journal Journal of Environmental Quality, vol. 26, no. 1, pp. 20-25, Feb 1997

Abstract Soil quality is emerging as an issue of vital importance to the use and management of land, water, and air. Clearly, we must maintain soils in a clean state that is suitable for agriculture, that minimizes the pollution of water and air, and that allows for the safe and productive use of wastes and by-products as soil amendments. We must also remediate many unclean soils that have been severely impacted by anthropogenic activities. It can be argued that to sensibly approach these complex tasks we must first begin to develop a consensus on the proper means to assess soil quality from an environmental perspective. In doing so we must quality will vary with the intended use of the land and will not always be the same for nonagricultural and agricultural systems. Measures of soil quality important for environmentally sound agronomic crop production will not always be the most appropriate for contaminated soils where cost-effective remediation is often the primary objective. This paper raises some fundamental questions about the changing role of soil scientists who now must contribute more than ever to the research, technology transfer, and public policy critical to soil and environmental quality. The need for soil scientists to take a proactive role in framing, from all perspectives, the debate on soil quality and environmental issues is emphasized, as is the need for new approaches to quantify the environmental risks posed by soils in agricultural and nonagricultural settings.

ArticleTitle Remediation of acid soils by using alkaline biosolids

Authors Sloan, J.J.; Basta, N.T.

Journal Journal of Environmental Quality, vol. 24, no. 6, pp. 1097-1103, Dec 1995

Abstract Alkaline biosolids may be suitable as a liming amendment for acid soils. The efficacy of two alkaline biosolids, lime-stabilized sewage sludge (LS) and N-Viro Soil (NV), for remediating soil acidity and Al toxicity in strongly acid soils were evaluated. For comparison, soils were also treated with unlimed anaerobically digested sewage sludge (SS) and agricultural lime (L). Three acid soils were amended with LS, NV, SS, and L and incubated at 25 degree C. Soil solution was extracted at 1, 30, 90, and 180 d incubation and analyzed for pH, electrical conductivity (EC), dissolved organic carbon (DOC), Al, Mn, Ca, Mg, Na, K, F, Cl, PO sub(4), NO sub(3), and SO sub(4). In general, soil pH increased linearly with amendment rate for all soils and all amendments. All amendments decreased soluble Al, but lime-containing amendments (LS, NV, and L) decreased soluble Al below detection limits (<0.4 mmol/L). The largest decreases in exchangeable Al were associated with lime-containing amendments. Lime-containing amendments reduced soluble Mn but unlimed sewage sludge had no effect on soil solution Mn. Soluble Al speciation using MINTEQA2 showed that all rates of lime-containing amendments (LS, NV, and L) decreased Al super(3+) activity to nontoxic levels (<10 mmol/L). Saturation indices indicated sewage sludge amendments may have resulted in precipitation of Al as alunite [KAl sub(3)(OH) sub(6)(SO sub(4)) sub(2) H sub(2)O]. Although SS decreased phytoavailable Al, alkaline biosolids caused greater reductions in potentially phytotoxic Al than nonalkaline biosolids (SS).

ArticleTitle Long-term effects of biosolids applications on heavy metal bioavailability in agricultural soils

Authors Sloan, J.J.; Dowdy, R.H.; Dolan, M.S.; Linden, D.R.

Journal Journal of Environmental Quality, vol. 26, no. 4, pp. 966-974, Jul 1997

Abstract Concerns exist over the long-term availability of trace metals in biosolids-amended soils. The objective of this study was to quantify extractable forms of trace metals in biosolids-amended, continuously cultivated soils after cessation of sewage sludge applications and to determine their bioavailability to romaine lettuce (*Lactuca saliva* L.). Trace metals in surface soils from two biosolids-amended sites were speciated into increasingly stable chemical fractions using a series of sequential extractions that were operationally defined as exchangeable (Exch), specifically adsorbed (SA), Fe-Mn oxide and acid replaceable (Ox/AR), residual organic (R-Org), and residual inorganic (R-In). Romaine lettuce was grown on the soils to determine heavy metal bioavailability. In control and biosolids-amended soils, 60 to 75% of Cd was found in the more easily extracted Exch and SA forms, but the percentage was significantly greater in the biosolids-amended soils. Biosolids applications also increased the percentages of Ni and Zn in the Exch and SA fractions. Biosolids applications had little effect on the Exch and SA fractions of Cr and Pb. Greater than 75% of Cr, Cu, Ni, Pb, and Zn were found in the relatively stable Ox/AR, R-Org, and R-In fractions of control and biosolids-amended soils. Concentrations of Cd, Ni, and Zn in aboveground lettuce tissue, and to a lesser extent, Cu and Cr, were significantly increased by biosolids applications, but Pb uptake was not affected.

ArticleTitle Rhizobium in soils contaminated with copper and zinc following the long-term application of sewage sludge and other organic wastes.

Authors Smith, S.R.

Journal Soil-biol-biochem. Oxford : Elsevier Science Ltd. Sept/Oct 1997. v. 29 (9/10) p. 1475-1489.

Abstract Soils from six long-term sewage sludge-treated sites contaminated principally with Cu and Zn, but containing only small concentrations of Cd, were screened for the presence of effective Rhizobium leguminosarum biovar trifolii using a plant infection assay for nodulation with Trifolium repens L. (white clover). Copper and Zn were determined as the elements most limiting to sewage sludge recycling on agricultural land, potentially reducing symbiotic N₂-fixation in sludge-treated soils. Soil samples contaminated with Cu and Zn from past applications of pig slurry, and with Cu due to historical treatment with 'pot-ale' (whisky distillery waste), were also assessed. Associations between the presence or absence of nodulation and the concentrations of Cu, Zn and Cd in soil were examined using a general linear modelling procedure to account also for variations due to the pH value and organic matter content of soil samples as well as the inherent variability between the different sampling sites. Rhizobium, effective in N₂-fixation, were present in all the soils supporting the host plant, irrespective of metal concentrations in soil which increased to 300 mg Cu kg⁻¹ and 2000 mg Zn kg⁻¹. In contrast, several soil samples with no indigenous host plant failed to nodulate white clover in the infection test, but the statistical analysis indicated that this was not associated generally with increased metal concentrations in soil or with greater metal 'availability' measured by soil solution analysis and metal uptake by five-leaf-stage barley plants. However, there was some limited evidence implicating Zn in the absence of nodulation at one of the sludge-amended sites examined. This work demonstrated that nodulation and effective N₂-fixation by white clover occurs in sludge-treated soils above the current U.K. maximum permissible concentrations of heavy metals.

ArticleTitle Effective Rhizobium leguminosarum biovar trifolii present in five soils contaminated with heavy metals from long-term applications of sewage sludge or metal mine spoil.

Authors Smith, S.R.; Giller, K.E.

Journal Soil-Biol-Biochem. Exeter : Pergamon Press. Aug 1992. v. 24 (8) p. 781-788.

Abstract The presence of effective strains of Rhizobium leguminosarum biovar trifolii was determined in a range of soils contaminated with heavy metals resulting from long-term applications of sewage sludge and also metal mine spoil, using an in vitro plant inoculation technique with Trifolium repens. Effective Rhizobium were always present in soil from sites where the host plant was established, irrespective of the amount of metal contamination. With no indigenous clover present, effective Rhizobium were also isolated from soils with concentrations of metals which exceeded the maximum permissible concentrations for sludge-treated soil. This may indicate Rhizobium strains had developed tolerance to elevated metal conditions without losing the ability to fix N₂ with white clover. However, elevated concentrations of Cd in soil apparently determined the absence of Rhizobium at one arable site as only half the soil samples taken nodulated white clover whereas increased concentrations of Zn and Cu had no effect in a soil low in Cd. Critical amounts of metals which resulted in a complete absence of Rhizobium in soil and nodulation could not be determined across the range of metal concentrations measured at each site. Therefore, detrimental effects of metals on Rhizobium were apparently site specific and there was no evidence that increased metal concentrations in soil selected for tolerant strains which were ineffective in N₂-fixation with white clover.

ArticleTitle Transformations of carbon, nitrogen, and metals in soils treated with waste materials

Authors Sommers, L.E.; Nelson, D.W.; Silveira, D.J.

Journal Journal of Environmental Quality (United States) v 8:3 . Jul 1979 p 287-294

Abstract Intact soil cores were used to evaluate decomposition, NH_3 volatilization, N transformations, and metal movement in soils treated with sewage sludges and antibiotic processing wastes. Soil cores were leached monthly with water and incubated for 1 year. An insignificant amount (< 1%) of the NH_4^+ applied was lost through NH_3 volatilization. The addition of wastes to five soils established that soil properties did not influence decomposition. In contrast, appreciable differences in decomposition were observed when different wastes were added to the same soil. Significant amounts of NO_3^- were leached from soils treated with antibiotic wastes, while essentially no NO_3^- leaching occurred in soils receiving sewage sludge, suggesting that denitrification and/or immobilization are major N loss mechanisms in soils treated with sewage sludge. Minimal amounts of P and metals were leached from sludge-amended soils. Soil analysis indicated that the majority of the added Zn, Cu, Cd, Ni, and Pb remained in the zone of sludge incorporation (0 to 7.5 cm) with minimal or no movement into the 7.5- to 15-cm soil depth.

ArticleTitle Removal and inactivation of Cryptosporidium oocysts by activated sludge treatment and anaerobic digestion.

Authors Stadterman, K L(a); Sninsky, A M; Sykora, J L; Jakubowski, W

Journal Water Science and Technology 31 (5-6): p 97-104 1995

Abstract

ArticleTitle Pharmaceuticals in the aquatic environment

Authors Stan, H.J.; Heberer, T.

Journal Analusis v 25:7, Sep 1997, pp. 20-23

Abstract Pharmaceutical residues are found as contaminants in sewage, surface, ground and drinking water. Drug residues originating from therapeutical use in human medical care are discharged into the aquatic system from municipal sewage treatment plants which act as point sources for surface water contaminations. Wherever contaminated surface water is used for groundwater recharge in drinking water production, the drug contaminants can also cause problems to drinking water supplies. Until now, the environmental assessment for this new class of contaminants is not clear or even regulated.

ArticleTitle Agronomic benefits of agricultural, municipal, and industrial by- products and their co-utilization: an overview

Authors Stratton, M.L.; Rechcigl, J.E.

Journal Beneficial Co-utilization of Agricultural, Municipal and Industrial By- products. Paper from Proc. 22nd Annual Beltsville Symp., held Beltsville, MD, USA, 4-8 May 1997. Brown, S. (ed). Kluwer Academic Publishers, (1998). pp. 9-34.

Abstract The beneficial use of agricultural, municipal and industrial wastes as a nutrient source in crop production, to improve soil properties or as an animal feedstock is examined in this review with 88 references. Particular attention is given to the utilisation and co-utilisation of these wastes in the USA. The characteristics and application of crop and animal residues, sewage sludge, water treatment effluents and solids, municipal solid waste (MSW) compost, household garden waste, energy production by-products, food processing wastes (eg cannery, coffee processing, brewing, slaughterhouse, dairy and fish processing wastes), by-products from the metals industries, fertiliser production wastes, paper and wood industry wastes (eg wastewater sludges and paper products), tannery wastes, textile industry wastes, building industry wastes (eg rock dusts and synthetic organic materials), chemical industry by-products (eg oily hydrocarbon sludges and pigment manufacture wastes) and by-products of antibiotic fermentation and drug production are considered with the aid of 22 tables.

ArticleTitle Removal of PCR inhibiting substances in sewage sludge amended soil.

Authors Straub, Timothy M; Pepper, Ian L; Gerba, Charles P

Journal Water Science and Technology 31 (5-6): p 311-315 1995

Abstract

ArticleTitle Concentration of medically used radionuclides in activated sludge at the megalopolis waste water treatment plants and estimation for the effective dose

Authors Suzuki, Takashi; Okano, Yasuhiro; Sugiura, Shiroharu; Inokoshi, Yukio

Journal Hoken Butsuri (Journal of Japan Health Physics Society) v 33:2 ., Jun 1998, p 163-170

Abstract The concentrations of medically used radionuclides in activated sludge samples were measured for 10 waste water treatment plants (WWTP) in Tokyo from October 1983 to March 1994. The nuclides [^{99m}Tc, [⁶⁷Ga, [¹¹¹In, [¹²³I], [¹³¹I] and [²⁰¹Tl], among others, could be detected, but these concentration levels were lower than the legal concentration limits in Japan. The excess activated sludge is usually incinerated at WWTP; then the resulting ash is transported for reclamation in Tokyo Bay. Internal and/or external exposure doses were evaluated for the following cases: The dose of the public attributed to radioactive iodine and [²⁰¹Tl], which were released from the incinerator by burning sludge; The dose of the workers during the process of transport and reclamation of the ash. As a result, the effective doses were sufficiently lower than the dose limit 1 mSv/y. The decay of the radionuclides were calculated over a period of curing of the landfill. It was found that the radionuclides had decayed out to approximately one nuclide. The effective dose of the public can therefore be ignored. Moreover, it was clarified that the effective dose of the public resulting from [^{99m}Tc is negligibly low in value at the present time. (author)

ArticleTitle Toxicity assays and their evaluation on organic polymer flocculants used for municipal sludge dewatering

Authors Takigami, H; Taniguchi, N; Shimizu, Y; Matsui, S; Grabow, WOK; Dohmann, M; Haas, C; Hall, ER; Lesouef, A; Orhon, D; Van Der Vlies, A; Watanabe, Y; Milburn, A; Purdon, CD; Nagle, PT

Journal WATER QUALITY INTERNATIONAL '98. PART 6. WATER QUALITY: ENVIRONMENTAL CONTAMINATION AND RESTORATION, Elsevier Science Ltd., Pergamon, P.O. Box 800, 1998, pp. 207-215, Water Science & Technology , vol. 38, no. 7

Abstract The toxicity of organic polymer flocculants used for the dewatering of municipal sludge was evaluated by using two different toxicity assays: the *Closterium ehrenbergii* algal toxicity test and the *Bacillus subtilis* rec-assay. The algal toxicity of the effluents from a pilot-scale sewage treatment plant was investigated with and without the addition of a flocculant (0, 0.05, 0.10 and 0.20 mg/L). No clear evidence on the toxicity caused by the flocculant was observed on both asexual and sexual reproduction tests of *C. ehrenbergii*. It was also found that the algal growth inhibition of various types of flocculants (i.e., cationic, anionic, amphoteric and non-ionic) was in the order of 1 to 20 mg/L, which was mainly due to a molecular weight (MW) fraction of greater than 100,000. The results of the *B. subtilis* rec-assay for these flocculants indicated that eight out of ten cationic flocculants caused the direct DNA damage with LC sub(50) = 0.1 to 10 mg/L. One of the genotoxic flocculants was also fractionated into their components by MW. The experimental results showed that the lethal effects were mainly contributed by the polymer fraction of MW greater than 100,000, although the genotoxicity was not detected in that fraction. Therefore, the detected genotoxicity of the flocculants could be caused by the combined effects of various components, such as polymers, oligomers, monomers and additives.

ArticleTitle Behaviour and occurrence of estrogens in municipal sewage treatment plants -- II. Aerobic batch experiments with activated sludge

Authors Ternes, T. A.; Kreckel, P.; Mueller, J.

Journal Science of the Total Environment , 1999 Vol. 225, No. 1-2 (January 12) , 91 Publication Year: 1999

Abstract Aerobic batch experiments containing a diluted slurry of activated sludge from a real sewage treatment plant (STP) near Frankfurt/Main were undertaken, in order to investigate the persistence of natural estrogens and contraceptives under aerobic conditions. The batch experiments showed that while in contact with activated sludge the natural estrogen 17beta-estradiol was oxidized to estrone, which was further eliminated in the batch experiments in an approximate linear time dependence. Further degradation products of estrone were not observed. 16alpha-hydroxyestrone was rapidly eliminated, again without detection of further degradation products. The contraceptive 17alpha-ethinylestradiol was principally persistent under the selected aerobic conditions, whereas mestranol was rapidly eliminated and small portions of 17alpha-ethinylestradiol were formed by demethylation. Additionally, two glucuronides of 17beta-estradiol (17beta-estradiol-17-glucuronide and 17beta-estradiol-3-glucuronide) were cleaved in contact with the diluted activated sludge solution and thus 17beta-estradiol was released. The glucuronidase activity of the activated sludge was further confirmed by the cleavage of 4-methylumbelliferyl-beta-D-glucuronide (MUF-beta-glucuronide) in a solution of a activated sludge slurry and Milli-Q-water (1:100, v/v). The turnover rate obtained was approximately steady state, with a turnover rate of 0.1 mu mol/l for the released MUF. Hence, it is very likely that the glucuronic acid moiety of 17beta-estradiol glucuronides and other estrogen glucuronides become cleaved in a real municipal STP, so that the concentrations of the free estrogens increase.

ArticleTitle Bacterial resistance as a biological indicator for heavy metals in environment

Authors Thriene, B.; Hellwig, A.; Weege, K.H.; Schulz, S.

Journal Forum Staedte-Hygiene (Germany, F.R.) v 40:6 Nov-Dec 1989 p 350-355, CONF-8910399--

Abstract This paper reviews about heavy metal-bacteria interactions in a variety of natural habitats such as river water, sewage, sewage sludge, sediment and soil as well as in the bacterial flora of human origin. Bacteria have developed very efficient and different resistance mechanisms for tolerating heavy metals mostly encoded by genes located on plasmids. Measurements of bacterial resistance to heavy metals can be a useful tool to indicate past and present exposures as well as to predict potential risks of environmental contaminants. The isolation of bacteria resistant to mercury, arsenic, silver, copper or chromium was done on an agar medium with a low metal binding capacity. Criteria for resistance were based on frequency distribution of minimal inhibitor concentration. We could show a relationship between metal contamination and the frequency of metal resistant bacteria. The isolation and characterization of plasmids which are involved in metal resistance are given in detail for mercury. Another aspect is the multiple resistance to both metals and antibiotics. We found that bacterial isolates of human origin with multiple antibiotic resistance are frequently resistant to mercury or arsenic. Therefore, there is a clinical significance of metal contamination in the environment. (orig./MG).

ArticleTitle Sewage sludge usage in cotton crop: I. Influence on soil properties.

Authors Tsadilas, C.D.; Dimoyiannis, D.G.; Samaras, V.

Journal Pedosphere vol. 9 (2): p.147-152, 1999.

Abstract A field experiment with cotton was conducted on a well drained, calcareous clay loam (Typic Xerochrept) in Greece to investigate the use of sewage sludge as a partial substitute for fertilizers and the influence of its application on the basic soil properties and heavy metal concentrations. The experimental design was completely randomized blocks with five treatments each replicated four times. The sewage sludge had the following characteristics: organic matter content 36.6%, pH (H₂O 1:5) 6.89, CaCO₃ 53.4 g kg⁻¹, total N 26.5 g kg⁻¹, total P 33.5 g kg⁻¹, and total K 968 mg kg⁻¹ soil. Heavy metal concentrations were Cd 5.24, Pb 442, Ni 38, Cu 224, Zn 1812, and Mn 260 mg kg⁻¹ dry weight. The soil was high in K and poor in available P. The results showed that sewage sludge application increased cotton yield and K and P concentrations in cotton leaves. Soil pH was reduced in the case of higher sewage sludge rate. Electrical conductivity, organic matter content, total N, and available P were significantly increased. Total concentrations of Zn, Pb, and Cu were slightly increased. DTPA-extractable Zn, Cu and Mn were also significantly increased. Available forms of all heavy metals, except Cd, were significantly correlated with organic matter content in a positive way and negatively with soil pH. 13 ref.

ArticleTitle The biodegradability and nontoxicity of carboxymethyl cellulose (DS 0.7) and intermediates

Authors Van Ginkel, C.G.; Gayton, S

Journal Environmental Toxicology and Chemistry, vol. 15, no. 3, pp. 270-274, 1996

Abstract Carboxymethyl cellulose (CMC) with a degree of substitution of 0.7 is a water-soluble polymer. In some cases, CMC ends up in wastewater treatment plants and, ultimately, in the environment. Carboxymethyl cellulose degrades completely at low rates in the environment as demonstrated in a prolonged closed bottle test and in a semicontinuous activated sludge test. The continuous-flow activated sludge (CAS) test simulates sewage treatment plants. In the CAS test the CMC added to raw sewage prior to entering the bioreactor was partly biodegraded by microorganisms. The effluent from the reactor containing intermediates was then used in standard aquatic toxicity tests. No toxicity was shown in the effluent, which indicates that the intermediates formed by biodegradation are not toxic. Carboxymethyl cellulose intermediates produced by a pure culture of a CMC-degrading bacterium were also shown not to be toxic, because no effects were observed at the highest concentrations tested: 0.5 g/L for *Selenastrum capricornutum* (algae), 1.0 g/L for *Daphnia magna* (water flea), and 1.0 g/L for *Brachydanio rerio* (zebra fish). In addition, the nontoxicity of CMC to these aquatic organisms was established with no-effect concentrations of > 0.5 g/L.

ArticleTitle Leaching of organic contaminants from contaminated soils and waste materials.

Authors Wahlstrom, M.; Thomassen, H.; Flyvbjerg, J.; Veltkamp, A.C.; Oscarsson, C.; Sundqvist, J.O.; Rood, G.A.

Journal Stud-environ-sci. Amsterdam ; New York, Elsevier Scientific Publishing Co. 1994. (60) p. 257-270.

Abstract

ArticleTitle Chlorobenzenes in Field Soil with a History of Multiple Sewage Sludge Applications

Authors Wang, Min-Jian; McGrath, S.P.; Jones, K. C.

Journal Environmental Science Technology v29, n2, p356(7) Feb 95

Abstract Soil samples were collected from a long-term field experiment in which multiple sludge applications were made. The samples were analyzed for concentrations of chlorobenzenes. Over the 30-yr application period, the concentrations of chlorobenzenes in the applied sewage sludges varied by more than one order of magnitude. The concentrations of individual chlorobenzenes in the soil samples were very low, except for 1,4-dichlorobenzene. Compared to control plots, however, the concentrations of all the chlorobenzenes in the sludge-amended soil samples increased and basically remained higher, indicating that multiple sludge applications did increase the contaminants of chlorobenzenes in soil to levels that remained detectable for at least 30 yr. A possible cause of the high 1,4-dichlorobenzene concentrations was that the compound may have entered the soil as an impurity in a pesticide formulation. The loss of hexachlorobenzene from the sludge-amended soil was found to continue for about 10 yr longer than the other chlorobenzenes.

ArticleTitle Organic contaminants and land application of municipal sludge in Canada.

Authors Webber, M

Journal U.S. ENVIRONMENTAL PROTECTION AGENCY MUNICIPAL WASTEWATER TREATMENT TECHNOLOGY FORUM., 1990, pp. 16-23

Abstract Applying municipal sludge on agricultural land is a cost-effective method of sludge use that recycles essential nutrients into the soil. It is practiced widely in Europe and the United States and accounts for one-third of Canadian sludge production. Organic contaminants (OCs) can enter sewerage systems through industrial and domestic effluents and remain in municipal sludge. OCs in sludges that are applied to agricultural land have the potential to enter the food chain and affect human and animal health. Sludge managers must, therefore, understand the persistence of OCs, their fate in soils, and how to apply sludges that contain OCs on agricultural lands.

ArticleTitle Waste metals - the Canadian approach to limiting metals on land from municipal sludges.

Authors Webber, M.D.

Journal WHAT'S NEW IN WASTEWATER TECHNOLOGY?., 1988, pp. 107-116

Abstract A summary of Canadian information concerning the production and agricultural utilization of municipal sludge is presented. Sludge quantities (1981) are estimated and waste guidelines for agricultural utilization are compared. Research findings on waste metal uptake by agricultural crops are reviewed. The future of agricultural utilization is considered.

ArticleTitle Persistence of volatile organic compounds in sludge treated soils

Authors Webber, M.D.; Goodin, J.D.; Fowlie, P.J.A.; Hong-You, R.L.; Legault, J.

Journal Water Quality Research Journal of Canada, vol. 32, no. 3, pp. 579-597, 1997

Abstract Laboratory incubation studies were conducted to assess the persistence of ten volatile organic compounds (VOCs) in seven soils treated with 3% dw of anaerobically digested municipal sludge. The VOCs were probable municipal sludge contaminants and the soils represented wide ranges of constituents likely to sorb organic compounds, e.g., organic carbon (1.3 to 12%) and clay (7 to 50%). The VOCs were spiked into soils at 50 mg kg super(-1) dw of soil, except for trichloroethylene and chloroform which were at 2.5 mg kg super(-1) dw. Three general patterns of VOC losses from soils were identified: (1) complete volatilization at room temperature within 24 h, (2) complete volatilization/degradation within 144 to 288 h, and (3) incomplete volatilization/degradation within 288 h. All VOC losses were consistent with first-order kinetics and indicated a combination of a rapid initial kinetic (0 to 4 h) followed by a slower kinetic. The slower kinetic was assumed to be more relevant to field VOC losses than the rapid kinetic, and first-order half-lives were calculated using the 4- to 288-h experimental data. The half-lives ranged from 5.5 to 1,926 h with a median value of 70 h, and generally increased with increasing boiling points of the VOCs and with increasing organic carbon contents of the soils. These laboratory findings indicate that VOCs in land-applied sludge are unlikely to represent a hazard to agriculture.

ArticleTitle Plant uptake of PCBs and other organic contaminants from sludge-treated coal refuse.

Authors Webber, M.D.; Pietz, R.I.; Granato, T.C.; Svoboda, M.L.

Journal Journal of Environmental Quality. 1994, 23: 5, 10191026; 15 ref.

Abstract A field study of industrial contaminant uptake by maize, cabbages and carrots was conducted in 1990 at the St. David Coal Refuse Pile Reclamation Site, Fulton County, Illinois, on 3 (of a total of 10) experimental plots which had received applications in 1987 of 785, 1570 and 3360 Mg/ha DW of Chicago municipal sewage sludge. Maize and cabbages grew well on all 3 treatments, however, carrots only grew on the 3360 Mg/ha DW sludge treatment. Both soil and plant tissues were analysed for PCBs, several pesticides, eg. alpha chlordane and DDE, polynuclear aromatic hydrocarbons (PAHs) and several other groups of organic contaminants. Mean soil PCB concn were $_4$ mg/kg DW and there was no consistent effect of sludge application rate. Samples from the 3360 Mg/ha DW sludge plot contained organochlorine pesticide concn of $_217$ μ g/kg DW and several PAHs at <1 to 3 mg/kg DW. Mean PCB concn in plant materials were <300 μ g/kg DW, however, there were differences among and within crops. Concn decreased in the order carrot peel $>$ carrot tops $>$ cabbage wrapper and inner leaves $>$ carrot core $>$ maize ear leaf and stover $>$ maize grain. Concn of PCB in maize grains was insignificant. Except for cabbage wrapper leaves, there was no correlation between concn of PCB in plant tissues and concn in the soil. No organochlorine pesticide residues were found in plant tissues from the 3360 Mg/ha DW sludge plot and except for indole and isophorone, only trace amounts of very few other organic contaminants were observed in plant materials. Despite the very large applications of municipal sewage sludge to this site, it was concluded that they did not result in excessive organic contamination in the treated coal refuse and that they presented no significant contamination hazard to the quality of food and feedstuffs grown thereon.

ArticleTitle Monitoring and prioritisation of organic contaminants in sewage sludges using specific chemical analysis and predictive, non-analytical methods.

Authors Webber, M.D.; Rogers, H.R.; Watts, C.D.; Boxall, A.B.A.; Davis, R.D.; Scoffin, R.; Jones, K. (ed.); Alcock, R.

Journal Organic contaminants in sewage sludges. Proceedings of International Symposium, Lancaster University, UK, 16-17 May 1995. Science-of-the-Total-Environment. 1996, 185: 1-3, 27-44; 31 ref.

Abstract A detailed monitoring survey was carried out to determine the concentrations of a range of industrial organic contaminants in 11 Canadian sewage sludges and one sludge compost. Volatile, base-neutral and acid extractable contaminants seldom exceeded 5 mg/kg DW organochlorine pesticides, polychlorinated biphenyls did not exceed 1 mg/kg DW and toxaphene and N-nitrosodimethylamine were not detected in the materials analysed. Mean total polychlorinated dibenzo-dioxin and polychlorinated dibenzofuran concentrations were 36 µg/kg DW and mean toxic equivalents were 0.12 µg/kg DW. It was concluded that in many Canadian sludges these organic contaminants represented no significant risk to agriculture and the environment. However, other organic contaminants potentially present in sewage sludge may not be amenable to analysis by the target compound techniques widely used. Consequently, a non-analytical approach was used to assess which contaminants may occur in sewage sludges and persist in treated soils. Predictions of physicochemical properties using quantitative structure activity relationships (QSARs) were used to aid the screening and prioritization of a range of high production volume chemicals (HPVCs) that may enter sewage treatment works. Analytical surveys for organic residues are expensive and this type of approach may assist in identifying further contaminants which should be analysed in sewage sludges and treated soils.

ArticleTitle Contamination of agricultural soils.

Authors Webber, M.D.; Singh, S.S.; Acton, D.F. (ed.); Gregorich, L.J

Journal The health of our soils: toward sustainable agriculture in Canada. 1995, 87-96.

Abstract The extent of organic and inorganic contamination of agricultural soils in Canada is considered. Soil from 8 national benchmark sites was used to monitor soil quality and soil from 6 intensively cropped farms in southern Ontario was analysed for 122 organic contaminants. Pesticide contamination of agricultural soil is not a serious problem in Canada. Generally, concentrations of organochlorine pesticides were <10 p.p.b. all soils analysed. There was little evidence of contamination of agricultural soils by nonpesticide compounds. There was a wide range of metal concentrations in Canadian topsoils. Heavy metals enter agricultural soils through atmospheric deposition and application of soil amendments (fertilizers, animal manures, and sewage sludge). Concentrations of heavy metals in soils varied with soil texture and soil order. Levels of contaminants, particularly heavy metals, in sewage sludge and receiving soils needed to be regulated. Guidelines for organic contaminant levels in sludge have not been developed in Canada, with the exception of Quebec.

ArticleTitle Industrial organic compounds in selected Canadian soils.

Authors Webber, M.D.; Wang, C.

Journal Canadian Journal of Soil Science. 1995, 75: 4, 513-524; 24 ref.

Abstract The concn of industrial organic compounds was determined in selected Canadian agricultural soils. The land application of municipal sludges was investigated to see if it caused significant polynuclear aromatic hydrocarbon (PAH), organochlorine pesticide (OC) or polychlorinated biphenyl (PCB) contamination of agricultural land. Twenty-four benchmark soils and six intensively cropped southern Ontario soils exhibited small concn of a few base-neutral and acid extractable industrial organic compounds (seldom > 1 mg/kg DW), PCBs (<200 µg/kg DW) and organophosphorus pesticides (OPs). Fonofos, the only OP detected, was observed at concn <100 µg/kg DW. Neutral and phenoxy acid herbicide analyses for 13 soils (seven benchmark and six intensively cropped) indicated infrequent detection of these compounds. There was no detection of carbamate herbicides. In most soils, only trace amounts (<10 µg/kg DW) of OCs were observed but in one intensively cropped soil. DDT exceeded 70 mg/kg DW. A greater incidence of alpha chlordane, dieldrin, aldrin and DDT in intensively cropped than in other soils reflected increased use of these compounds for intensive crop production. Soils treated with sludge, according to recommended practice, showed minor increases in PAH, OC and PCB concn. There was no risk to human health or the environment from industrial organic compounds, except DDT, in Canadian agricultural soils that had received no sludge or from PAHs, OCs and PCBs in soils that had received southern Ontario sludges according to recommended practice.

ArticleTitle Midges and flies of a sewage sludge treated field.

Authors Weber, G; Prescher, S

Journal Agrarökologie, VERLAG PAUL HAUPT, BERN (SWITZERLAND), 1995, no. 15, 100 pp.

Abstract Biology, phenology and taxonomic composition of the dipteran fauna of an arable field treated with sewage sludge near Braunschweig were investigated using a number of methods. The insects were caught from 1988 to 1990 using soil emergence traps. The traps were placed on plots treated with two different quantities of sewage sludge (4 t/ha and 12 t/ha dry weight respectively), with and without the application of additional heavy metals. There was also an untreated control plot. In 1988 the crop was spring wheat, in 1989 maize and in 1990 potatoes. Baits for ovipositing females were exposed on the investigation site and subsequently kept in laboratory emergence traps to catch the developing adults. The soil emergence traps yielded 12.441 (1988), 14.545 (1989) and 8.484 (1990) individual dipterans encompassing 12 families of Nematocera and 27 families of Brachycera. In all three years Cecidomyiidae, Chironomidae and Sciaridae were the three most abundant Nematocera families. The abundance of Chironomidae and Sciaridae was distinctly increased by sewage sludge and also by heavy metals at the applied concentrations used here. With respect to sewage sludge, this was also true for some families caught in low individual numbers. The catches of Cecidomyiidae suggest that the abundance of this family was only slightly increased by sewage sludge and not influenced by the heavy metals. Among the Brachycera, 61 - 73 % belonged to the family Phoridae. The Hybotidae, Sphaeroceridae and Drosophilidae were also abundant. Except for the Hybotidae, the highest numbers of individuals of all these families emerged on the plots with the higher amount of sewage sludge and fewest on the control plot without sewage sludge. The heavy metals in the soil possibly caused a decrease in the abundance of two species of the families Phoridae and Drosophilidae. The contamination had no effect on Hybotidae, Sphaeroceridae or other species of Phoridae. The increase in abundance of the above families associated with sewage sludge is due to the enrichment of the soil with organic matter as well as an increase in soil moisture. The reasons for the higher abundance of Sciaridae and Chironomidae on the plots with additional heavy metals may be due to a reduction in food competitors or an effect on the soil microflora. In the laboratory emergence traps numerous adult Diptera developed, especially of the families Sciaridae, Psychodidae, Sphaeroceridae and Drosophilidae. Among them were several species which did not occur in the soil traps.

ArticleTitle Bioavailability of heavy metals and arbuscular mycorrhiza in a sewage-sludge-amended sandy soil

Authors Weissenhorn, I; Mench, M; Leyval, C

Journal Soil Biology and Biochemistry, vol. 27, no. 3, pp. 287-296, 1995

Abstract The bioavailability of metals (Cd, Ni, Zn, Cu, Pb and Mn) and abundance of arbuscular mycorrhiza were studied in a long-term sewage-sludge field trial on an acid sandy soil, at INRA-Bordeaux, France. Zn/Mn-(E1) and Cd/Ni-(E2)contaminated sludge had been applied at two rates (10 t DM ha super(-1) y super(-1) and 100 t DM ha super(-1) 2y super(-1)) for 18 and 5 y, respectively. Inorganic fertilizer and farm yard manure treatments served as unpolluted controls. Soil extraction with EDTA-NH sub(4)OAc and Ca(NO sub(3)) sub(2) and plant (Zea mays L.) uptake demonstrated an unusually high Zn (E1), Cd and Ni (E2) availability in the sludge-amended plots. The spore density of arbuscular mycorrhizal fungi ranged from 16 to 67 spores 50 g super(-1) dry soil, and root colonization between 0-33%. No relationship between mycorrhizal abundance and degree of metal exposure in soil or inside plant roots could be established, but root colonization across the different treatments correlated well with plant P status. The results suggest a better tolerance of the indigenous population of arbuscular mycorrhizal fungi to elevated metal than to high P concentrations.

ArticleTitle Evaluation of Nitrogen Availability in Irradiated Sewage Sludge, Sludge Compost and Manure Compost.

Authors Wen Guang(a); Bates Thomas E; Voroney R Paul

Journal Journal of Environmental Quality 24 (3): p 527-534 1995

Abstract A field experiment was conducted during 2 yr to determine plant availability of organic N from organic wastes, and effects of gamma irradiation on organic N availability in sewage sludge. The wastes investigated were: digested, dewatered sewage sludge (DSS), irradiated sewage sludge (DISS), irradiated, composted sewage sludge (DICSS), and composted livestock manure (CLM). The annual application rates were: 10, 20, 30, and 40 Mg solids ha⁻¹. Fertilizer N was added to the control, to which no waste was applied, as well as to the waste applications to ensure approximately equal amounts of available N (110 kg N ha⁻¹) for all treatments. Lettuce (*Lactuca indica* L.) petunias (*Petunia times hybrida* Vilm.), and bean (*Phaseolus vulgaris* L.) were grown in 1990 and two cuts of lettuce were harvested in 1991. Crop yields and plant N concentrations were measured. Assuming that crop N harvested/available N applied would be approximately equal for the control and the waste treatments, the N from organic fraction of the wastes, which is as available as that in fertilizer, was estimated. With petunia in 1990 and the combination of first and second cut of lettuce in 1991, the percentage ranged from 11.2 to 29.7 in nonirradiated sludge, 10.1 to 14.0 in irradiated sludge, 10.5 to 32.1 in sludge compost and 10.0 to 19.7 in manure compost. Most often, the highest values were obtained with the lowest application rates. Yields of petunia and N concentrations in second cut lettuce in 1991 were lower with irradiated sludge than with nonirradiated sludge suggest that the availability of organic N in digested sludge may have been reduced after irradiation. Irradiation of sludge appears to have released NH₄⁺-N. The availability of organic N, however, appears to have been reduced by irradiation by greater amount than the increase in NH₄⁺-N.

ArticleTitle Comparison of phosphorus availability with application of sewage sludge, sludge compost, and manure compost.

Authors Wen Guang; Bates, T. E.; Voroney, R. P.; Winter, J. P.; Schellenbert, M. P.

Journal Communications in Soil Science and Plant Analysis vol. 28 (17/18): p.1481-1497, 1997, 36 Ref.

Abstract Digested, dewatered sewage sludge (DSS); irradiated sewage sludge (DISS); irradiated and composted sewage sludge (DICSS); and composted livestock manure (CLM) were applied for two years at five rates (0, 10, 20, 30, 40 t/ha per year) in a field experiment in Ontario, Canada. Uptake of P was measured in lettuce cv. Grand Rapids, bean (*Phaseolus vulgaris* cv. Tender Green, and *Petunia hybrida* cv. Superior Red in 1990, and in consecutively harvested two cuts of lettuce in 1991. Percentage of total P that was extractable by 0.5M NaHCO₃ in CLM (30-70%) was much higher than in DSS, DISS, and DICSS (0.8-5.6%). Phosphorus uptake by crops harvested in an early stage of growth, lettuce in 1990 and first cut lettuce in 1991, and the extractable soil P linearly increased with total P applied. The lack of response in P uptake with bean pod and petunia in 1990, and the second cut lettuce in 1991, was possibly due to their advanced stage of maturity. Much larger amounts of P were applied with DSS, DISS, and DICSS than with CLM, while P uptake and extractable soil P did not increase compared to that in the treatment that received no P. The low availability of P in sludge was probably caused by Fe and Al which precipitated P. Sludge irradiation and/or composting had no significant effect on P availability.

ArticleTitle Airborne Microbiol Populations During Land Application of Municipal Sewage Sludge

Authors Widmer, KW; Ricke, SC; Pillai, SD

Journal 95th General Meeting of the American Society for Microbiology, Washington, D.C., USA, May 21-25, 1995. Abstracts of the General Meeting of the General Meeting of the American Society for Microbiology; 95 (0). 1995. 464.

Abstract

ArticleTitle Polynuclear aromatic hydrocarbon uptake by carrots grown in sludge-amended soil.

Authors Wild, S.R.; Jones, K.C.

Journal Journal Environmental Quality. Madison, Wis. : American Society of Agronomy. Apr/June 1992. v. 21 (2) p. 217-225.

Abstract The uptake of polynuclear aromatic hydrocarbons (PAHs) from sewage sludge-amended soils by carrots (*Daucus carota*) was investigated. Carrots were grown in control soils and sods amended with three sludge application rates, 15, 55, and 180 t/ha. Applied sludge contained 17.2 mg sigma PAH/kg, a concentration typical for a sludge derived from a rural area. Carrot foliage, root peels and root cores were analyzed for 15 PAH compounds. Carrots foliage PAH concentrations were unaffected by sludge applications (PAH loadings), but root peel PAH concentrations increased to a plateau concentration with increasing soil PAH levels. Low molecular weight PAH compounds dominated individual components of the sigma PAH load in the root tissues. The PAH concentrations detected in the root peels were all significantly lower than in the foliage, which receives PAH inputs from the atmosphere. Carrot core sigma PAH concentrations were unaffected by sludge application, implying little or no transfer of PAHs from the peels to the core. About 70% of the PAH burden found in carrots was associated with the peels. Fresh weight carrot core concentrations were all < 4.2 micrograms/kg. Overall, this investigation suggests that the risks posed to human health by PAHs applied in sewage sludge to arable soils are minimal.

ArticleTitle Effects of non-pesticide organic pollutants on soil microbial activity.

Authors Wilke, B.M.; Auerswald, K. (ed.); Stanjek, H. (ed.); Bigham, J.

Journal Soils and environment - soil processes from mineral to landscape scale. International Soils and Environment Conference, Weihenstephan, Germany, 23-25 October 1995. *Advances-in-Geoecology*. 1996, No. 30, 117-132; 18 ref.

Abstract The effects of synthetic surfactants, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs) on soil microorganisms and microbial activity of soils are described. Linear alkylbenzenesulfonate (LAS) and nonylphenol reduced microbial activity at concentrations ≈ 10 mg/kg soil, while the nonylphenolethoxylate Marlophene 812 was effective at ≈ 50 mg/kg soil. Because of its strong adsorption in soil the cationic surfactant DSDMAC was not toxic in soils. Under natural conditions e.g. after application of sewage sludge, only LAS could reduce the microbial activity in soils. Pure culture and agar plate experiments showed that PCBs and PAHs may affect the growth of fungi and bacteria at concentrations >0.1 mg/litre agar. Positive as well as negative effects were obtained. PCBs were less toxic to soil fungi than PAH. In soils the effects of PCBs and PAHs on soil microbial processes were limited by their low water solubility and their strong adsorption to organic material. As a rule, their effectiveness to reduce microbial activity of soils decreased with decreasing water solubility and increasing hydrophobicity. Nevertheless, reductions of microbial activity were obtained at concentration of <1 mg/kg soil (e.g. Fluoranthene, PCB 1). Moreover, the toxicity of PCBs and PAHs was modified by various factors such as sensitivity of microbial populations, pH, and dissolved organic C concentrations in soil solution.

ArticleTitle Sewage Sludge As A Potential Source Of Lead In Liver Kidney And Muscle Tissues Of Growing Lambs

Authors Wilkinson, M; Hill, J; Livesey, CT; Stark, BA; Curran, MK; Lean, IJ; Hall, JE

Journal 112th Meeting of the British Society of Animal Science, Scarborough, England, UK, March 18-20, 1996. *Animal Science (Pencaitland)*; 62 (3). 1996. 666.

Abstract

ArticleTitle Persistence of organic contaminants in sewage sludge-amended soil: a field experiment.

Authors Wilson, S.C.; Alcock, R.E.; Sewart, A.P.; Jones, K.C.

Journal *Journal of Environmental Quality*. 1997, 26: 6, 1467-1477; 33 ref.

Abstract Digested sludge was applied to ploughed arable and pasture grassland plots in the UK and losses of specific volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and chlorophenols (CPs) monitored over 260 d. Sludge addition increased soil concentrations of all compounds in the ploughed plot. VOCs, PCBs, and CPs concentrations declined to control plot values within 128 d of sludge amendment. Volatilization and biodegradation were considered important loss processes for these compounds. However, PCDD/F and of non-o-PCB 77 concentrations did not change consistently and remained elevated above control plot concentrations throughout the monitoring period. At Day 260 410 ± 53 ng SIGMAPCDD/kg and 250 ± 10 ng SIGMAPCDF/kg was detected in the sludged plot compared to 68 ± 9 ng SIGMAPCDD/kg and 170 ± 7 ng SIGMAPCDF/kg in the control plot. Data from the pasture plot were highly variable and differences between most contaminant concentrations in the sludged and control plots were insignificant. This was attributed to adherence of much of the applied sludge to vegetation rather than direct application to the soil surface and has important implications for elevated dietary intake of certain persistent organic compounds such as the PCDD/Fs. Contaminant movement to depth (20 cm) was not detected within 260 d for compounds monitored (VOCs and PCDD/Fs).

ArticleTitle Screening the environmental fate of organic contaminants in sewage sludges applied to agricultural soils: 1. The potential for downward movement to groundwaters

Authors Wilson, S.C.; Duarte-Davidson, R.; Jones, K.C.

Journal Science of the Total Environment , vol. 185, no. 1-3, June 1996, pp. 45-57.

Abstract The potential for organic contaminants present in sewage sludge to leach and cause groundwater contamination following sludge application to agricultural land has been assessed. Models used to predict compound mobility in soil on the basis of physico-chemical parameters were applied to a range of contaminants prioritised and /or detected in sludge and a provisional list of potential 'leachers' compiled. In addition, theoretical soil water concentrations following sludge application were calculated using mean reported sludge contaminant concentrations and soil/water partition coefficients. These estimated aqueous phase concentrations were compared with Dutch groundwater quality standards in the absence of appropriate UK standards to identify those compounds which could be present in groundwater at levels of concern. The two prioritised lists were used to identify compounds in sludge which could pose a possible threat to groundwater. Appropriate experimental data were not available to qualify model results. However, the screening exercise indicated that under routine operational practice with typical sludge application rates, and the usual range of compound concentrations detected in sludge, groundwater quality standards were unlikely to be exceeded. However, data variability, reliability and scarcity limited the usefulness of this screening approach.

ArticleTitle Towards zero accumulation of heavy metals in soils: an imperative or a fad.

Authors Witter, E.

Journal Fertil-res. Dordrecht : Kluwer Academic Publishers. 1995/1996. v. 43 (1/3) p. 225-233.

Abstract Sweden has recently introduced new guidelines for the agricultural use of sewage sludge which contain successively more restrictive metal loading rates for soils. At the same time further efforts are made to reduce the input of heavy metals through atmospheric deposition and fertiliser use. The proposed metal loading limits are among the most restrictive in the world, although other Scandinavian countries and the Netherlands have proposed similarly low limits. It is the aim of the Swedish Environmental Protection Board to successively reduce the metal load of soils until a situation of zero accumulation is reached. With the possible exception for Cd, there is apparently no scientific evidence at the moment to suggest that zero accumulation of metals in soil is required to adequately protect soil productivity, the environment, and human and animal health. A policy which steers towards zero accumulation may therefore seem excessively cautious. It is, however, also a policy which recognises the practically irreversible nature of elevated heavy metal concentrations and their effects in soil, the deficiencies in the evidence currently available with which to establish safe metal loadings for soils, as well as the need to preserve the agronomic value of soils for many years to come. It is argued that the use of restrictive annual metal loading rates can be used to effectively ensure that maximum soil concentrations or cumulative pollutant loadings, considered to be safe are not reached in the foreseeable future.

ArticleTitle Terrestrial risk assessment for linear alkyl benzene sulfonate (LAS) in sludge-amended soils.

Authors Wolf-W-de; Feijtel, T; De-Wolf, W

Journal Chemosphere. 1998, 36: 6, 1319-1343; 44 ref.

Abstract Processes that critically influence the fate of the surfactant LAS in the terrestrial environment are reviewed, with particular reference to LAS released from sewage sludge after its application to land. Factors to be accounted for during an environmental assessment and that require further investigation are examined. Topics include: the influence of aerobic conditions on changes in LAS concentrations during sludge storage; aerobic biodegradation in soil; sorption processes which affect both the LAS residence times in soil and the expression of its effects towards benthic and soil dwelling organisms and plants. The chemical form of LAS in the environment differs from that used in commercial detergents because differential sorption and biodegradation leads to a shift in the alkyl chain length (homologue), and phenyl-isomer distribution towards increased hydrophobicity. Occurrence of Ca/Mg-salts in the environment vs. the Na-salt for the commercial material critically impacts the extrapolation of effects data obtained in lab studies (mostly performed with the commercial material) to the field. The literature data were used to help predict the environmental concentrations of LAS entering the soil system through sludge applications. Soil biodegradation is considered a necessary element in the 'predicted environmental concentration' (PEC) calculations for LAS. The initial realistic worst case assessment presented indicates no human health risks exists with indirect exposure to LAS through either food or drinking water. Current LAS use does not pose a risk to terrestrial organisms such as plants and invertebrates.

ArticleTitle Land disposal of sewage sludge: pathogen considerations.

Authors Yates, M.

Journal Environmental Toxicology Newsletter. Berkeley, Calif. : Cooperative Extension, University of California. May 1992. v. 12 (2) p. 1-2.

Abstract