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Heavy metals and microbial loads in raw fecal sludge from low income areas of Ashanti Region of Ghana

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Abstract

This study was carried out to determine the heavy metals and microbial loads of raw public toilet sludge from low income areas (peri-urban and rural) of Ashanti Region of Ghana. Fecal sludges were sampled from public toilets. Methods outlined in Standard Methods for the Examination of Water and Wastewaters were used for the analyses of fecal sludge samples. Range of heavy metals concentrations were found as 0.039–5.216 mg/l and 0.010–1.488 mg/l for peri-urban and rural areas, respectively. These concentrations were in the order of Mn > > Cu > > Fe > > Zn > > Pb > > Ar > > Cd and Zn > > Mn > > Fe > > Cu > > Pb > > Ar > > Cd for peri-urban and rural areas, respectively. The range of bacteria loads was measured as 1.4×10^6–4.5×10^7 CFU/100 ml for peri-urban and 0.2×10^6–4.5×10^7 CFU/100 ml for rural areas. Similarly, range of helminths was determined as 1–18 eggs/100 ml for both peri-urban and rural areas. The study showed that the levels of heavy metals and microbial quantities were generally higher in peri-urban compared to rural areas. However, fecal sludge from these low income areas are not recommended for direct use in agriculture unless they are given further treatment. Composting is recommended as a promising and suitable method for effective treatment of fecal sludge resulting in a hygienically safe and economically profitable product.

Key words: fecal sludge, heavy metals, low income, microbial loads

INTRODUCTION

A large proportion of fecal sludge generated from onsite sanitation systems are not properly disposed of. An onsite sanitation system is defined as a system of sanitation where the means of storage are contained within the plot occupied by the dwelling and its immediate surroundings (WHO 2006). It may be disposed of on site or removed manually for safe disposal (WHO 2006). About 85% of the Ghanaian population is served by onsite sanitation systems (EAWAG and SANDEC 2006), including latrines, non-sewered public toilets and septic tanks. Unregulated disposal of fecal matter can cause nuisance and serious health impacts due to pollution of water sources where a significant proportion of the population in these countries depend on untreated water sources (Odai & Dugbantey 2003).

As noted by Pescod (1971), Pradt (1971), Um & Kim (1986), Guo *et al.* (1991) and Strauss *et al.* (1997), the characteristics of collected fecal sludges vary greatly and depends on, among others, the season, type of on-site sanitation system (e.g., water closet/septic tank system, dry aqua privy, watertight vented pit latrines), emptying frequency (i.e., is the retention time in the facility), the

The eggs contained in the fecal sludge are not always infectious but are infectious when they are viable and the lavae develops. Similarly, the prevalence of the eggs could be attributed to human origin. Fecal sludge from peri-urban areas generally exhibited more numbers of eggs compared to that of rural areas (Figure 5).

CONCLUSIONS

Results from the study showed that the levels of heavy metals and microbial quantities were generally higher in peri-urban areas compared to rural areas. The variations in monitored parameters could be explained by a high sludge age or a high retention time of sludge in rural public toilets which may increase the mortality of fecal microorganisms. However, fecal sludge from both peri-urban and rural areas generally exceeds the Ghana EPA maximum permissible limits. This means that fecal sludges are not recommended for direct use in agriculture unless they are given further treatment. Composting is recommended as a promising and suitable method for effective treatment of fecal sludge resulting in a hygienically safe and economically profitable product.

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REFERENCES

APHA-AWWA-WEF. 2005 *Standard Methods for the Examination of Water and Wastewater*, 21st edn. APHA-AWWA-WEF, Washington, D.C.

Appiah-Effah, E., Nyarko, K. B., Gyasi, S. F. & Awuah, E. 2014 Faecal sludge management in low income areas: a case study of three districts in the Ashanti region of Ghana. *J. Water Sanit. Hyg. Dev.* **4**, 189–199.

ATSDR. 1999 *Toxicology Profile for Mercury, March and April 1999 Media Advisory, New MRLS for toxic substances*. Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, Atlanta, GA.

Bell, C. & Kyriakides, A. 2002 *Salmonella*: *A Practical Approach to the Organism and its Control in Foods*. Blackwell Science, Oxford.

Carrondo, M. J. T., Lester, J. N., Perry, R. & Stoveland, S. 1978 *Analysis of Heavy Metals in Sewage Sludge, Sewages and Final Effluent*. Final Report to the Department of the Environment for Contracts. Public Health and Water Resource Engineering Section, Civil Engineering Department, Imperial College, London, UK.

Dean, R. & Lund, E. 1981 *Water Reuse*. Academic Press, New York.

Dima, G., Popescu Ion, V., Stihi, C., Oros, C., Dinu, S., Manea, L. & Vlaicu, G. 2006 Fe, Mn and Zn concentrations determination from Ialomipa River by atomic absorption spectroscopy. *Rom. J. Phys.* **51**, 667–674.

EAWAG and SANDEC. 2006 Urban Excreta Management - Situation, Challenges, and Promising Solutions. *1st International Faecal Sludge Management Policy Symposium and Workshop, Dakar, Senegal, 9–12 May*.

Environment Agency. 2004 *The Microbiology of Sewage Sludge (2004) - Part 4 -Methods for the detection, isolation and enumeration of Salmonella. Methods for the Examination of Waters and Associated Materials*. Environment Agency, Exeter, UK.

Environmental Factsheet. 2003 *Fecal Coliform as an Indicator Organism*. Department of Environmental Services, Concord, NH.

Guillemet, T. A., Maesen, P., Delcarte, E., Lognay, G. C., Gillet, A., Claustriaux, J. & Culot, M. 2009 Factors influencing microbiological and chemical composition of South-Belgian raw sludge. *Biotechnol. Agron. Soc. Environ.* **13** (2), 249–255.

Guo, S. B., Chen, R. Z., Li, G. & Shoichi, H. Y. 1991 Approach to the reforms in nightsoil treatment process introduced abroad. *Water Sci. Technol.* **24** (5), 189–196.

Hashem, A. R. 2000 Microbial and mineral content of sewage sludge from Riyadh and Yanbu, Saudi Arabia. *Emir. J. Agric. Sci.* **12**, 33–41.

doi: 10.2166/wpt.2015.014

Jensen, R., Buffangeix, D. & Covi, G. 1976 Measuring water content of feces by the Karl Fischer method. *Clin. Chem.* **22** (8), 1351–1354.

Kuffour, A. R., Awuah, E., Adamtey, N., Anyemedu, F. O. K. & Kone, D. 2013 Agricultural potential of biosolids generated from dewatering of faecal sludge on unplanted filter beds. *Civil Environ. Res.* **3** (5), 10–17.

Lopez Zavala, M. A. 2002 Characterization of feces for describing the aerobic biodegradation of feces. *J. Environ. Syst. Eng.* **720**, 99–105.

Macneal, W., Latzer, L. & Kerr, J. 1909 The fecal bacteria of healthy men. Introduction and direct quantitative observations. *J. Infect. Dis.* **6**, 123–169.

Mountassir, Y., Benyaich, A., Rezrazi, M., Berçot, P. & Gebrati, L. 2013 Wastewater effluent characteristics from Moroccan textile industry. *Water Sci. Technol.* **67** (12), 2791–2799.

Nemerow, N. L. 1978 Industrial Water Pollution: Origins, Characteristics, and Treatment. Addison-Wesley Publishing, Reading, MA, 1978.

Odai, S. N. & Dugbantey, D. D. 2003 Towards pollution reduction in peri-urban water supply: A case study of Ashanti region in Ghana. *In: Diffuse Pollution and Basin Management. 7th International Specialised IWA Conference, Dublin, Ireland.*

Öğleni, N. & Özdemir, S. 2009 Pathogen reduction effects of solar drying and soil application in sewage sludge. *Turk. J. Agr. For.* **34**, 509.

Olatunji, S. & Osibanjo, O. 2012 Determination of selected heavy metals in inland fresh water of lower River Niger drainage in water of lower River Niger drainage in North Central Nigeria. *N. Afr. J. Environ. Sci. Technol.* **6** (10), 403–408.

Pescod, M. B. 1971 Sludge handling and disposal in tropical developing countries. *J. Water Pollut. Control Fed.* **43** (4), 555–570.

Pierce, J. J., Weiner, R. F. & Vesihind, A. P. 1998 *Environmental Pollution and Control*, 4th edn. Butterworth-Heinemann, Boston, MA, pp. 167–244.

Pradt, L. A. 1971 Some recent developments in night soil treatment. *Water Res.* **5**, 507–521.

Sasakova, N., Juris, P., Papajova, I., Vargova, M., Ondrasovicova, O., Ondrasovic, M., Kaskova, A. & Szabova, E. 2005 Parasitological and bacteriological risks to animal and human health arising from wastewater treatment plants. *Helminthol* **42** (3), 137–142.

Schwartzbrod, J., Stien, J. L., Bouhoum, K. & Baleux, B. 1989 Impact of wastewater treatment on helminth eggs. *Water Sci. Technol.* **21** (3), 295–297.

Stephen, A. M. & Cummings, J. H. 1980 The microbial contribution to human faecal mass. *J. Med. Microbiol.* **13** (1), 45–56.

Strauss, M., Larmie, S. A. & Heinss, U. 1997 Treatment of sludge from on-site sanitation, low cost options. *Water Sci. Technol.* **36** (6), 129–136.

Ulmgren, L. 2000a Stockholm Water Company. Measures taken in smaller industries to avoid hazardous substances entering domestic wastewater systems. Paper presented 25 May 2000, del Instituto de Ingenierá, UNAM, Mexico.

Ulmgren, L. 2000b Stockholm Water Company. Wastewater treatment and steps taken in practice for reducing sludge contamination in Stockholm, Sweden. Paper presented 27–28 March 2000, at the Conference Traitamiento de lodos de depuradora:su minimización, valorización y destino final.

Um, W. T. & Kim, S. W. 1986 Night soil treatment in Korea. *Water Sci. Technol.* **18** (7–8), 13–22.

Volk, W. & Wheeler, M. 1988 *Basic Microbiology*. Harper Row Publishing, New York, USA.

WHO 2006 *World Health Organization Guidelines for the safe use of wastewater, excreta and greywater*, Policy and regulatory Aspects, Annex 1-Glossary of terms used in the guidelines. WHO Press, Geneva.

Wolna-Maruwka, A. 2008 Estimation of microbiological status of sewage sludge subject to composting process in controlled conditions. *Pol. J. Environ. Stud.* **18** (2), 279–288.

Woodbury, P. B. 1992 Trace elements in municipal solid waste composts: a review of potential detrimental effects on plants, soil biota, and water quality. *Biomass and Bioenergy*. **3**, 239–259.

Wyman, J. B., Heaton, K. W., Manning, A. P. & Wicks, A. C. 1978 Variability of colonic function in healthy subjects. *Gut* **19** (2), 146–150.