Iranian J Publ Health, Vol. 33, No. 1, pp.5-9, 2004

Waste Sludge Characteristics of a Wastewater Treatment Plant Compared with Environmental Standards

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Abstract

Sludge production is an avoidable problem arising from the treatment of wastewater. The sludge remained after municipal wastewater treatment contains considerable amounts of various contaminants and if is not properly handled and disposed, it may produce extensive health hazards. On the other hand, this sludge has benefits for plants and soils. Thereupon, land application of sludge has received much attention over the traditional incineration and dump in sea. The comprehensive regulations of U.S.EPA title 40 CFR parts 503 include criteria and standards for land application of sludge. One of the most important wastewater treatment plants in Tehran, Iran is Shoosh Plant, which applies its waste sludge in agricultural lands after dewatering in drying beds. In this research, waste sludge from drying beds was examined according to 40 CFR parts 503. Results indicate that the dehydrated sludge has not the characteristics required for final discharge. If the dewatering process in the existing beds of the plant would be modified according to title 40 CFR part 503, the standard of Pathogen Reduction class B would be achieved. Waste sludge of drying bed must be applied in agricultural land with respect to the conditions of application method that is presented in vector attraction reduction. Concentration of this waste sludge is less than ceiling concentration limits identified by title 40 CFR parts 503.

Keywords: *Municipal sewage sludge, Sludge disposal, Land application, Shoosh wastewater treatment plant*

Introduction

Sludge production is unavoidable problem arising from the treatment of municipal wastewater. This sludge contains considerable amounts of organic matter, pathogens and chemical contaminants which if is not properly handled and disposed may produce extensive health hazards (1). Sludge disposal is now recognized to be as one of the most important problems by all environmentalists and in this regard new standards have been established by USEPA in 1989. Moreover, more concise and restrictive regulations are executed every year for this purpose. Incineration, for example, has been confined and dump in sea has been prohibited in EU and USA. Instead, land application of the sludge has received much more attention (2). This method, namely land application of the sludge, may cause various health and environmental problems, which should be considered as well. USEPA regulations title 40 CFR parts 503 describes the matter and explains: definitions, purpose and applicability, general requirements, pollutant limits, management practices, operational standards, pathogen and vector attraction reduction, sampling and analysis, frequency of monitoring, recordkeeping, and reporting (3).

But in Iran, there is no written law about sludge although they are mainly being applied in lands. Thereupon, we deem it necessary for this study to select one of the most important treatment plants of Tehran namely Shoosh Plant in order to have a criteria to compare the characteristics of the enormous sludge produced at this Plant with the comprehensive standards of USEPA –

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40 CFR 503. The present study for Tehran was accomplished for the first time but a similar research has been practiced before in Isfahan Treatment Plant (4). For advanced countries, the monitoring of sludge before its application on land is a routine compulsory practice. Shoosh plant is located in Kianshahr place (Shoosh) in the south of Tehran city, and has an average inflow of 388 m^3 h^{-1}. There are four tanks for aeration of wastewater and three tanks for clarification, which establish the activated sludge units of this Plant. The waste sludge of these units is directed to 10 drying beds. The sludge retention at these beds is 2 to 3 months in summers and 3 to 5 months in winters, and there is no another sludge stabilization process in Shoosh Plant. After drying, the sludge is kept at depot and before final disposal is mixed with soil. Finally, it is applied on agricultural lands of Ray region. According to USEPA - 40 CFR 503 standards, the sludge should be examined for the following criteria: Pathogen Reduction, Vector Attraction Reduction, and Pollutant Limits. Qualitative analysis of the sludge before its land application is a very important task that should be fulfilled by comparison of results with existing standards and later selection of disposal site and evaluation of disposal parameters such as loading rate (5).

Materials and Methods

Sampling of the sludge has been done after asking permission from the Tehran Water and Wastewater Engineering Company. Towenty samples have been taken from dewatered sludge of the Shoosh Plant during spring, summer and autumn of 2002 before final disposal (after 3 to 5 months of retention in drying beds). At least 7 samples require for sludge analysis according to USEPA - 40 CFR 503 standards. This work has been done manually by composite sampling from the middle depths of different parts of the sludge bed. Vessels used for this sampling were of plastic kind with screw caps (6). Selection the volume of samples and the other conditions required for sampling were all in accordance with the recommendations outlined in Standard Methods for the Examination of Water and Wastewater (7). The analyses have performed in Chemistry and Microbiology Laboratories of Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences (TUMS). Totally 10 samples taken in 4 months have been analyzed. All of the sludge samples have been prepared for analysis by accomplishing dehydration process, screening and grinding.

But the preparation stages have not been performed for such analyses as pH, total solids, and volatile solids (8, 9). The analyses of concern were as follows:

pH by electrometer (mixtures of sludge and distilled water, 1 to 2.5 by weigh, according to directions of Soil and Water Research Institute) (8), Total and volatile solids by gravimetric methods (8), Total Kjeldahl nitrogen by macro Kjeldahl method (8), Total phosphorous by visual spectrophotometry (phosphomolybdate ammonium) (8), Heavy metals including cadmium, chromium, copper, nickel, lead, and zinc using wet digestion method by atomic absorption spectrophotometry (7), Helminthes egg identification by sedimentation technique and later examination by microscope according to directions of Dept. of Parasitology, TUMS, and Total and fecal coliform group by multiple - tube - fermentation technique as mentioned previously (7).

Results

The average values determined for results of qualitative analyses of disposed sludge in comparison with USEPA - 40 CFR 503 standards are given in Table 1. As none of the Vector Attraction Reduction conditions is respected at Shoosh Plant, so the sludge produced can not be examined in this regard. Nevertheless, this sludge should be observed for the required criteria of Vector Attraction Reduction before it could be applied on lands.

Table 1: The mean values for results of qualitative analyses of disposed sludge

Characteristics	Unit	Mean values	Recommended values (Standard 40-CFR 503)
pH	-	7.6	
Total Solids	%	56.9	
Total Volatile Solids	%TS (a)	41.9	
Total Kjeldahl Nitrogen	%TS	1.43	
Total Phosphorus	%TS	0.7	
Total Coliform	MPN/1gr ds (b)	20,500,000	
			Class A : < 1000
Fecal Coliform	MPN / 1gr ds	2,016,543	Class B : <2,000,000
Helminth Eggs	N / 4gr TS (c)	-	Class A : < 1
Heavy Metals			
Cd		0.1	85
Cr		125.2	3000
Cu	mg / kg DS (d)	1400.5	4300
Ni		312.4	420
Pb		247.7	480
Zn		549.1	-

(a) Percent of Total Solids
(b) Most Probable Number per 1 gram of dry solids
(c) Number per 4 gram of Total Solids
(d) Milligram per kilogram of dry solids

Discussion

The following conclusions are developed for disposed sludge of Shoosh samples after comparison with standard 40CFR 503:

Pathogen reduction in comparison with standard The sludge having the Pathogen Reduction Standards of class A and B is suitable for applying on agricultural lands and soil amendment. Time restrictions are placed on harvesting crops, grazing of animals, and public access to site on which class B sludge is applied (10). These restrictions are recommended in order to be sure for enough reduction of resistant pathogens and helminthes egg (11). According to standard class A Pathogen Reduction, less than 1000 fecal coliforms per gram of total solids or less than 3 *Salmonella* per 4 grams of total solids of the sludge has been recommended. But the geometric average values of fecal coliforms of Shoosh disposed sludge are much more than this limit, so standard class A can not be met. Besides, there would be no need to inspect the other part of this standard related to associate alternatives. The class A treatment alternatives include treating the sludge for a specified time and temperature combination, heat-enhanced alkaline stabilization, treatments by Process to Further Reduction Pathogen (PFRP), and use of processes that are proven to reduce virus plaque-forming units and helminthes ova to less than 1 per 4 grams of sludge (10). PFRPs include composting, heat treatment, thermophilic aerobic digestion, beta-ray irradiation, and pasteurization, which none of them is applied on Shoosh Plant. According to class B standard of Pathogen Reduction, the geometric mean value of fecal coliforms for at least 7 samples has been recommended to be less than 2 millions per gram of sludge solids, or there would be need to treat the sludge by Process to Significantly Reduce Pathogens (PSRP) or similar processes. The PSRPs include aerobic digestion, air drying, anaerobic digestion, composting, and lime stabilization (10). But for Shoosh disposed sludge this geometric mean

value is slightly more so it is not expected that class B standard would be regarded. If the sludge drying which itself is a PSRP process could be proceed perfectly, the class B standard would be attained because the insignificant difference will become diminished. According to USEPA, the sludge drying in air could be considered as one of the PSRP processes if the minimum retention time of 3 months for drying is regarded and the average value of daily temperature in this period is not dropped bellow zero.

Vector attraction reduction in comparison with standard In order to dispose bio-solids (class A and class B) which complying with standard 40CFR 503, one of the twelve alternatives for Vector Attraction Reduction must be met (3). As none of the conditions required for Vector Attraction Reduction is respected at *Shoosh* Treatment Plant, so the sludge can not be examined in this regard. The disposed sludge should be applied on lands only after observing the requirements (conditions 9 to 11), which are related to application methods (3).

Comparison with pollutant limits standard To be land applied, bulk sewage sludge must meet the pollutant Ceiling Concentration Limits and Cumulative Pollutant Loading Rate for determining the application rates. Application rate for bulk sewage sludge applied to lawn and home gardens is Pollutant Concentration Limits based on average value in month, and for sewage sludge sold or given away in bags it must meet the Pollutant Concentration Limits or the Annual Pollutant Loading Rates (10). Design sludge loading rates for application to agricultural or to nonagricultural lands will be controlled by the pollutant limits or by the nutrient loading rates (nitrogen and phosphorous limits) necessary to meet vegetation requirements(5). As it is presented in table 1, the heavy metals concentrations of disposed sludge are less than the Ceiling Concentration of 40 CFR 503 standard. The metal concentrations and nutrient contents of the sludge disposed from drying beds of Shoosh Plant are used in determining the loading rate of the sludge for land application.

Finally, our recommendations include the following For meeting the class B standard of pathogen reduction, retaining the waste sludge of Shoosh Plant in exiting drying beds for at least 3 months is a necessary practice and there would be need to prolong this time whenever the temperature is dropped bellow zero. With respect to the need of developing agricultural lands in Iran and the space limitations, it seems as though that land application of municipal wastewater sludge in exiting fields would be a very suitable alternative for final sludge disposal if necessary precautions were respected. Different alternatives for sludge disposal should be distinguished by considering directives of USEPA, but final definitions and standards must only be adopted after considering local conditions the qualitative and quantitative characteristics of the sludge disposed from municipal wastewater treatment plants are to be examined on a routine basis and regularly if the sludge is intended for land application.

Acknowledgments

The authors thank the following professors and participants for their collaborations in this research: Dr. Iraj Mobedi, Associate Professor of Department of Medical Parasitology and Mycology, School of Public Health, Tehran University of Medical Sciences, Dr. Emami, Institute of Soil and Water Research, Dr. Moazzeni, Tehran Water and Wastewater Eng. Co., Mr. Esbah, Director of Shoosh Wastewater Treatment Plant and all the staff of Water Quality Control Laboratories of the School of Public Health who contributed to the accomplishing the required analyses.

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