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Investigation some Properties of Shahin-Shahr Sewage Sludge For Land Application–Isfahan, Iran

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ABSTRACT

Background: Land application of sewage sludge is still one of the most important disposal options in most countries. Although, land application of sludge allows the nutrients of sludge to be used beneficially, but pollutants and pathogenic organisms can raise the health risk.The aim of this study was to investigate the suitability of using dried sewage sludge of Isfahan wastewater plans as a fertilizer in agricultural lands.
Methods: Samples were collected from Shahin-Shahr WWTPs[1] in 2012, seasonally. Micro-biochemical parameters were measured for each site.
Results: Total and fecal coliforms did not classify in any standard ranges. The pH, nitrogen, phosphor, potassium, calcium, total solid, organic matter and moisture were classified in normal ranges except for magnesium. The carbon to nitrogen ratios ranged from 7.41-9.45. It was significantly lower than the normal range.Organic nitrogen composed the highest percentage of the total nitrogen (about 78%) and inorganic nitrogen was in normal ranges. The electrical conductivity ranged from 5-8.8.It may contribute to soil salinization in long term. Seasonal variations showed the maximum nitrogen and phosphor was in winter. Minimum and maximum of potassium, calcium and magnesium were recorded in spring.
Conclusion: Application of sewage sludge of Isfahan waste water treatment plans as a fertilizer could be useful regardless to its microbial contents because it provides essential nutrients for plants growth regardless to its fecal and total coliforms.
KEYWORDS: EPA[2] standards, Shahinshahr WWTPs, Dried sewage sludge, Quality, Fertilizer.

INTRODUCTION

Organic maters have important roles in soil properties such as preserving water and nutrients and preventing soil degradation. Since the dry land suffers from low organic matter, content, using of biological compounds is common way to improve the soil composition in terms of organic matter and nutrient instead of applying chemical fertilizers. Using of sewage sludge could be positive through a good management policy about the keeping international standard levels of physicochemical and microbial parameters; however the risks of the toxic matters should not be ignored. Therefore, monitoring of these compounds and theirenvironment fate is critical issue to get comprehensive knowledge about its application benefits or limitationsas agricultural fertilizer.

Sewage sludge or biosolids, are produced during the biological treatment of sewage, contain significant quantities of organic matter, moisture, nutrients and trace elements, and as such are increasingly being viewed as a resource for agricultural and municipal sectors [1]The aim of treating sludge is transferring it to neutral which no aromatic compounds lost its water easily [2]. The methods for sludge treatment depends on wastewater treatment plan (WWTP) characters such as location, type, size, number of active sections, volume of the sewage sludge, its composition and disposal methods [3]

In recent decades, the WWTPs are developing because of increasing wastewater generation[4], so managers have concerned about its environmental risks.Previous studies reported that United States of America, European United Nations, Japan, Taiwan and Korea produced annually 7, 8, 3.5, 0.2 and 2.43 million tons dried biosolidsrespectively [5; 6; 7].

Farzadkia et al.[8]studied on four Tehran WWTPs and reported that nearly all of sewage disposed without any efficient treatment. Another approach on Isfahan WWTPs sludge showed aerobic digesters could supply the treatment at pathogen standard levels of Environment Protect Agency (class B), while these digester did not supply any standard criteria in South America WWTPs [9].

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However, disposing of sewage sludge has being an environmental crisis in recent years, they consist of many nourish components such as nitrogen and phosphor which effect plant functions and bio-physicochemical properties of soil [10; 11; 12]. Therefore, application of the sewage sludge as a fertilizer in agricultural land acts as two side's effects indisposing and potential use of the biosolids[13]. As they could be used as nutrients for the soil and plant with the definite assurance that pathogen microorganisms (bacteria and virus), heavy metal and organic pollutants remain at their standard levels. The bioavailability of heavy metals in soil and ground waters depending on their concentrations in soil solutions. It effects on their plant uptake in response of their different distributions [14; 15].

In Iran, 50 WWTPs established by the 2002 and they increased to 75 by the end of 2003. Thereforethe generation of wastewater increased significantly and there is a constant need to increase knowledge about suitable disposal solutions[16]. Nevertheless burning, disposing in sanitary sites and using in agricultural land are the most common disposal options. Type of treatments, distance of WWTPs from the land and eco-social factors should be considered for land disposing management and decreasing the environmental risks [17; 18]. There are limited data on Isfahan WWTPs sludge quality; therefore this study was carried to investigate the suitability of sewage sludge application for agricultural land.

MATERIALS AND METHODS

This study was carried out from July 2012 to October 2013. The actual capacities was 24820000 cubic meters for Shahin-Shahr WWTPs. The sewage was produced through the process dividing into two main parts including primary and secondary treatments.

Dried sewage samples were collected seasonally (with 3 replications) using sterilized bottles (containers) and then kept in freezer at 4^0C to prevent any change in sludge conditions [19; 20].

Micro-biochemical parameters were measured including total and fecal coliforms (counts), pH, electrical conductivity (ds/m), total solid (%), moisture (%), organic matters (%), nitrogen (%), phosphor (%), calcium (%), magnesium (%), potassium (%), nitrate, ammonium and organic nitrogen (%) and carbon-nitrogen ratio (%) [19; 20].

Data was checked for normality distribution with the Kolmogorov-Smirnov test. Comparison the biochemical data and standard level (EPA) analyzed by using two tailed t-test, assuming a significant level of α=0.05 by SPSS 17 software package.

RESULTS AND DISCUSSION

Selected properties of sewage sludge

The mean values and ranges for pH, total solids, organic matters and moisture were summarized in Table 1. Almost all of the parameters showed significant differences in except of organic matters. The maximum organic matters was 45.8. It reveals that anaerobic digestion and stabilization is followed weakly in Shahin-Shahr WWTPs. The other reason for this fact is low pH values of the WWTPs[21; 22].

Table 1. Some physical properties of sewage sludge - Shahin-Shahr WWTPs

parameters			P value	t	Bina et al. (2004)
	Mean	Min-Max			Min-max
pH	6.66	6.3-7	0.088n.s	-1.889	6-9
Total solids (%)	62.62	61.8-63.4	0.614n.s	0.538	50-70
Organic matters (%)	37.05	22.7-45.8	0.873n.s	-0.168	25-50
Moisture (%)	37.38	36.6-38.2	0.614n.s	-0.538	30-50

n.s= no significant difference, ** significant difference at α=0.01 and * significant difference at α=0.05

Generally the properties of sewage sludge depend on quality of the sewage sludge and involved preparing or treatment processes. The sludge is produced in different compounds from suspension sludge with 4% total solids to 90% total solids. Therefore, the moisture will be 20-50% subsequently. In this study, the total solids and moisture was approximately 60 and 40 percent. It shows that the Shahin-Shahr WWTPs are able to produce sludge with a high percentage of dry matters.

The pH could effect on plant and soil uptakes, so it changes the microbial populations in the soil. Since the low pH values (up to 6.5) results in more leaching and plant uptake of heavy metals [23],it can infer that the pH of Shahin-Shahr WWTPs has no risk for plant uptake of heavy metals.

The parameters of each wastewater treatment plan were comprised with standard levels reported by Bina et al. [2] (Figure1). According to the results, the values were in normal ranges. The results of physical parameters confirm that using of the sewage sludge as a fertilizer is not restricted from this point view.

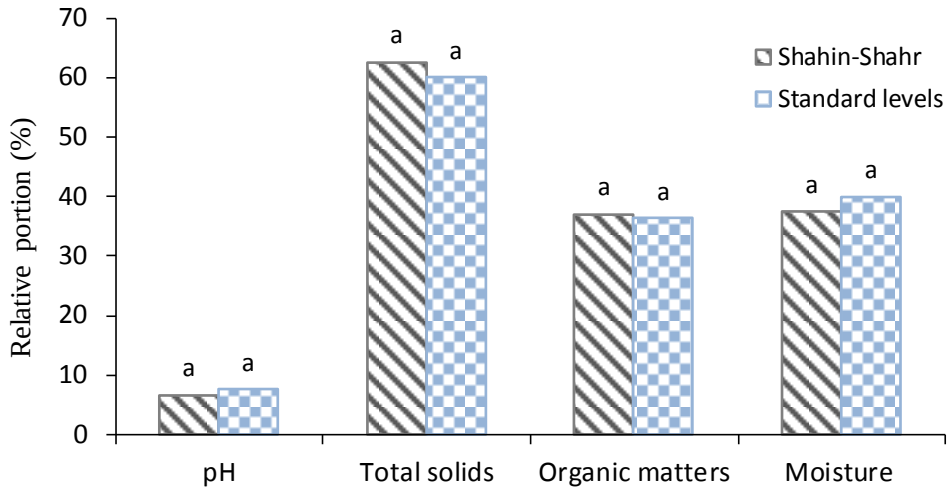

Figure 1. Comparison of physical parameters of Shahin-Shahr sludge with standard levels

Sewage sludge quality as a fertilizer

The results of sewage sludge components are given in Table 2. Seasonally variations of the Shahin-Shahr sludge showed that the minimum and maximum values of potassium, calcium and magnesium were in spring and summer respectively. They showed similar variations in different seasons. In spring, nearly all of components were the lowest.

Table 2. Sewage sludge quality of Shahin-Shahr WWTP

Seasons	Parameters	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Spring	Mean	1.36	1.38	0.39	1.56	0.21
	Min-Max	1.32-1.4	1.25-1.51	0.28-0.5	1.4-1.6	0.19-0.22
Summer	Mean	2	1.31	1.07	1.88	0.3
	Min-Max	1.32-1.74	1.08-1.54	0.73-1.18	1.72-2.17	0.23-0.34
Autumn	Mean	2.97	1.36	0.53	1.86	0.27
	Min-Max	2.41-3.81	1.15-1.7	0.4-0.6	1.6-1.95	0.25-0.28
Winter	Mean	3.02	1.53	0.6	1.57	0.27
	Min-Max	1.93-3.81	1.24-1.75	0.55-0.65	1.3-1.65	0.26-0.28
Annually	Mean	2.16	1.33	0.58	1.7	0.27
	Min-Max	1.32-3.81	1.08-1.75	0.28-1.18	1.3-2.17	0.19-0.34
Bina et al. (2004)	Min-Max	0.1-3.5	0.3-3.5	0.1-2.8	----	----
P value		$0.49^{n.s}$	$0.137^{n.s}$	0.000^{**}	----	----
Sullivan (1998)	Min-Max	3-8	1.5-3	0.1-0.6	1-4	0.4-0.8
P value		$0.78^{n.s}$	$0.918^{n.s}$	0.000^{**}	0.015^{*}	0.000^{**}

n.s= no significant difference, ** significant difference at α=0.01 and * significant difference at α=0.05

Comparisons of the sludge quality parameters with standard levels [2; 24] showed that potassium, calcium and magnesium were lower than standard levels significantly ($p<0.01$ and $p<0.05$). Other parameters did not show any significantly differences. Overally the quality parameters were in the standard ranges. Therefore using Shahin-Shahr sewage sludge as a fertilizer is not restricted.

The results confirm that Shahin-Shahr sewage sludge has a good potential for using as an agricultural fertilizer.

According to previous studies, using sewage sludge (15-20 tons per ha) in Borkhar area, nitrogen, phosphor, potassium, calcium and magnesium added to the soil is 468, 280, 130, 344 and 52 kg/ha. This data shows the Shahin-Shahr sewage sludge are rich sources nutrient contents as a fertilizer except for magnesium and potassium.

The average value of carbon in Shahin-Shahr sewage sludge were 21.5% (13.2-26.6) (Table 3)and was in the normal ranges [2]. According to the standard level (8-50%), the carbon was relatively low in samples. Also, the carbon-nitrogen ratio (C/N) of Shahin-Shahr plan were calculated 8.24 (7.41-9.45) which was lower than Bina et al. [2] levels. Totally, the lower C/N results in decreasing nitrogen uptake by microorganism and plant competition.

Organic nitrogen, calculated by the difference between total and inorganic (nitrate and ammonium nitrogen), was the dominate form of nitrogen in the sludge (77-78%). The result was accordance with EPA [23]. Both of inorganic forms of nitrogen (nitrate and ammonium) were not restricted based on Sommers [25] and Furr et al. [26]. The ammonium was higher than nitrate nitrogen (5 times).

Generally inorganic and organic nitrogen depend on the sludge treatment and its usage [23]. The organic nitrogen does not change during drying process but the inorganic ones change. For example the ammonium nitrogen decreases because of evaporating during drying process or the nitrate nitrogen decreases during dewatering [23].

Electrical conductivity in sludge samples varied from 5 to 8.8 (ds/m). Comparison of the results with previous studies confirms that it might salinize the soil [23; 27]

Table 3. Some properties of sewage sludge as a fertilizer

Parameter	C/N	EC (ds/m)	Ammonium nitrogen (%)	Nitrate nitrogen (%)	Organic nitrogen (%)	Carbon (%)
Min-Max	6.8-9.43	5-8.8	0.088-0.36	0.01-0.098	1.74-3.81	13.2-26.6
Average	8.24	6.55	0.2	0.038	2.43	21.53
Bina et al., 2004	20	---	---	---	---	8-50
Furr et al., 1976	---	---	0.65	0.05	---	---
P value	0.000^{**}	---	0.000^{**}	$0.36^{n.s}$	---	$0.177^{n.s}$

n.s= no significant difference, ** significant difference at α=0.01 and * significant difference at α=0.05.

Microbial properties of sewage sludge

The mean values of total and fecal coliforms are shown in Table 4. The minimum and maximum values were recorded in summer and winter, respectively. According to EPA, sewage sludge used as an agricultural fertilizer must have total coliform up to 1000 (class A) and use the sewage classified in B class (1000-2000000) is restricted and some limitations must be considered. However the coliform count higher than 2000000 is not suitable as a fertilizer.

According to Table 5, total coliforms were not in A and B classes (more than 2000000).

Since in the microbial properties showed high value of coliforms counts (more than 2000000), waste water treatment plants should employ selected technical methods to remove pathogens and it is suggested that the sewage sludge should not dispose into any place where has environmental conflicts. The result was accordance with AsadiArdali et al., [28];Farzadkia et al., [8] andMesdaghinia et al., [29].Although Takdastan et al. [9] and Bina et al. [2] reported that the sewage sludge classified in B group at North Isfahan and Shahin-Shahr, respectively.

The following, treatment process for improving the microbial properties of the sewage sludge is suggested:

1. Increasing the sewage retention time in driers or disposal place.
2. Considering the limiting fertilizers application especially in crops contacted with fertilizer-induced soils directly.
3. Labors should be trained for sanitary points in sewage application at WWTPs and agricultural land.

Finally, we suggest monitor and analyze the crops produced in this fertilizer-induced soils to measure the effects of this fertilizer on crops quality and soil to understand its long term effects.

Table 4. Microbial properties of sewage sludge

Sample site	Parameter	Total coliforms (MPN/g)	Fecal Coliforms (MPN/g)
Shahin-Shahr	Min-Max	146.3×10^{2}-460×10^{8}	146.3×10^{2}-240×10^{8}
	Average	233×10^{8}	111×10^{8}

Conclusions

In summary, the sewage sludge is a rich source of nutrient matters (nitrogen, phosphor, potassium, calcium, magnesium and organic matters), so its applications could support plant growth, increase organic matters of soil. Also it improves the moisture and nutrients contents of the soil and its air and water infiltrations (physicochemical properties).

Therefore, it seems Shahin-Shahr sewage sludge has a good potential for applying them as agricultural fertilizer regardless to their microbial counts. Improving some treatment processes are suggested to eliminate the limitations.

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Endnotes

[1-] WWTPs: Waste Water Treatment Plans
[2-] EPA: Environmental Protection Agency

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