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ORIGINAL ARTICLE

Reduction of adverse environmental impacts caused by urban sewage: application of green soil fertilizers

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This research was designed with the aim of feasibility study on the production of safe fertilizers from urban sewage sludge in Isfahan refinery and assessment of the nutritional value of produced fertilizers in comparison with standard. For this purpose, the effects of different ratios of sewage sludge and manure on different treatments (including: 0, 25, 40, 55, 70 and 85 % wt/wt) along with 15 % bulking materials (including dry residues of Pine trees and grass waste) were tested in a randomized complete block design with three replications for a period of 75 days. Then, the nutrients content of each treatment was measured according to standard methods. The results showed that the concentration of heavy elements in the vermicompost produced in all treatments was lower than the standard recommended by EPA. The concentration of nutrients (total phosphorus and potassium, organic carbon, iron, zinc, copper, manganese) was very high in different treatments up to the application level of 70%. However, with increasing sludge consumption from 70% to 85%, the C / N ratio decreased significantly. Based on these results, an application of 70% sludge with 15% manure and 15% bulking material in a vermicompost production site can be used to produce a biological fertilizer with high fertilizer value and reduces the accumulation of sludge and environmental damage.
Key words: vermicompost fertilizer; sewage sludge; soil pollution; environmental management

Introduction

Many large amounts of sludge were produced annually from the urban wastewater recycling system of the Isfahan refinery, which is finally buried near the refinery (Hosseini Panah and et al, 2015). This sludge contains large amounts of pollutants for the environment and therefore has potential for soil and groundwater contamination. The application of production technology of biological fertilizer of vermicompost from sewage sludge while reducing the contamination caused by these compounds is considered as one of the optimal and economical options (Parvanak Borujeni, 2010). Atiyeh and et al (2010) first in Germany and then in the United States in 2009 conducted continuous research on the ability of various types of earthworms to process organic waste (Khwairakpam and Bhargava, 2009). Loh and et al (2005) in Toronto, Canada, built an industrial system to produce organic fertilizers (Mehrdadfar, 2008). In the field of the production of biological fertilizers from slime in Iran, in the past years, the production of semi-industrial products has been scattered in Tehran, Karaj and Mashhad. Most of them are half-finished and for various reasons abandoned (Rejali and Khavarezzi, 2010).

Ndegwa and Thomson (2000) in their laboratory studies observed the active sludge vermicompost: almost one gram of live earthworms can convert four grams of active sludge to vermicompost within five days. Yahya Beidaki and Norouzi Masiri (2005) discussed the possibility of using sewage sludge to produce vermicompost and suggested that the concentrations of iron, zinc, phosphorus, and potassium increased significantly compared to the control (without sludge). According to the results of pilot studies, Pramanik (2010) found that vermicompost production process is effective in the treatment and stabilization of sludge from dairy and paper industry, in condition of mixing with bovine wastes.

The results of Raja Sekar and Karmegam (2014) research towards effect of vermicompost on the environment and crop showed that the use of this fertilizer had no effect on the environment and crop but improved the physical and chemical conditions of soil and vegetation. Research results of Saha et al. (2008) in the study of urban sewage sludge stabilization by Vermicompost process, proved that the primary and secondary sewage sludge mixture with a moisture content of more than 95% is also usually have more than 70% of organic matter with high nitrogen and phosphorous content but less organic carbon than urban waste applied to feed the vermicompost. The current research was designed with the general purpose of investigating the reduction of adverse environmental impacts of urban wastewater through the production of safe fertilizers applicable to landscape soils.

Materials and Methods

To achieve the desired goal in this study, the experiment was a randomized complete block design with three replications in greenhouse conditions in 2016. For this purpose, the sewage sludge of the refinery was sampled to the required extent and transferred to the laboratory. Its physical, chemical and biological characteristics were measured according to standard methods (Page, 2001; Leo et al., 2007). Sewage sludge with different percentages (0, 25, 40, 55, 70, and 85 % wt/wt) was mixed with food and cow manure and poured into pots of with a length of 40 and a diameter of 30 cm. After the preparation of the quality *Eisenia fetida* cream, about 150 healthy worms were added to each pot. Pots in greenhouse conditions maintained. Care and nourishment of the worms during the processing period (about 3 months). Then the cream was separated from the fertilizer and the quantitative and qualitative indices of fertilizer (P, K, C/N, Fe, Zn, Cu, Mn, and Ni) were measured according to standard methods. Statistical analysis of the measured data was done using MSTA-C software and LSD test at 5% level.

Results and Discussion

Physical and chemical properties of sewage sludge studied

The results of the physical and chemical analysis performed on the refinery sewage sludge sample are compared with the standard values in Table 1. It should be noted that sewage sludge has a neutral pH and electric conductivity (EC) is small. Carbon/Nitrogen (C/N) sludge has exceeded the standard. The amount of nitrogen, phosphorus and potassium sludge in the refinery is within the standard range.

Table 1. Physicochemical properties of sewage sludge studied

Mn	ZN	Cu	Fe	Ni	K (%)	P (%)	C/N	ECe dSm^{-1}	pH	Element
mg/kg										
120	1100	270	9950	48	0.38	2.1	23.8	3.1	7.45	Existing values in sewage sludge studied
260	2800	1500	1100	420	0.1-.28	0.3-0.5	20	8	6-9	Standard values in sewage sludge

Study of changes in carbon-nitrogen (C/N) ratio of vermicompost

The highest rate of C/N ratio of vermicompost produced in sewage sludge without treatment (C/N=24/1) was observed, which is higher than the standard application of sludge for agricultural use (the permitted limit of 1/20). With the addition of sewage sludge to the bed, the rate of C/N decreased (Fig. 1), so that the lowest amount was related to treatment with application of 85% sludge (C/N =10/1).

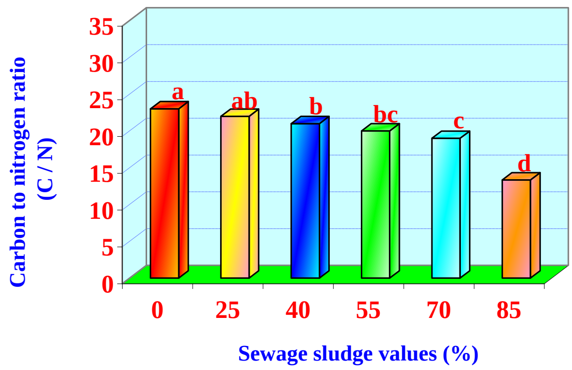

Fig. 1. Comparison of the mean ratio of C/N produced vermicompost for different amounts of sludge. Here and further the same letters in the charts indicate that there is no significant difference at the 1% probability level (through the LSD test).

Study of changes in total phosphorus and total potassium vermicompost

Based on the average comparison results (Figs 2a, 2b), are considered, with increasing amount of sludge from 0% level to 85%, the amount of total phosphorus (Pt) and potassium (Kt) produced by vermicompost increased significantly at 1% level (pr<0.01). The presence of a large number of microflora and phosphorus soluble enzymes in the intestines of earthworms can be an important factor in increasing the total phosphorus and potassium content of vermicompost.

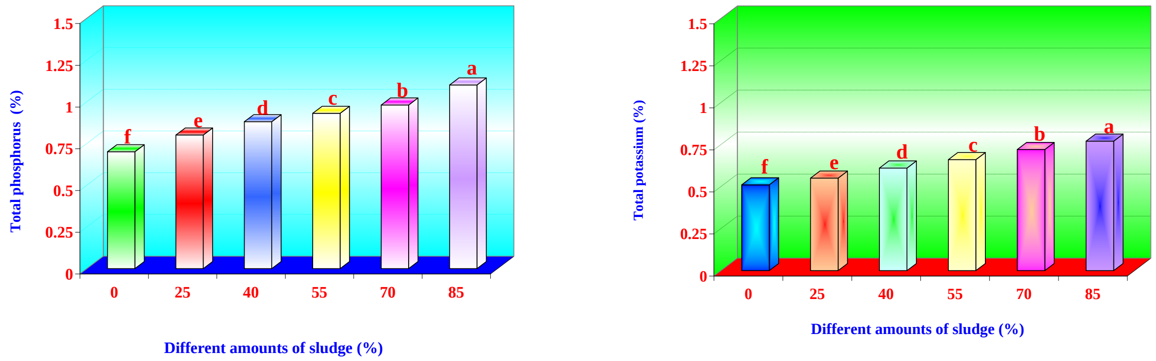

Fig. 2. Comparison of mean total phosphorus (Pt) and total potassium (Kt) produced vermicompost for different amounts of sludge.

Changes in the concentration of heavy metals (micro elements) in vermicompost

The results of the comparison presented in Figs 3a, 3b, 3c, and 3d. With the use of sludge up to 25% and 40%, the amount of iron, zinc, copper, manganese and nickel in vermicompost increased compared to zero sludge application, However, this increase was not statistically significant at 1% (pr>0.01). With increasing amount of sludge from the level of 0% to 55%, 70%, and 85%, the concentration of these elements in vermicompost was significantly increased (pr <0.01).

The highest number of elements was observed in 85% sludge treatment which did not show significant difference with 70% sludge treatment (pr> 0.01). The increase of these elements up to 85% of the application of sludge in vermicompost was less than the standard recommended by the EPA and it was not until there was a problem in terms of absorbing these elements by plant or soil.

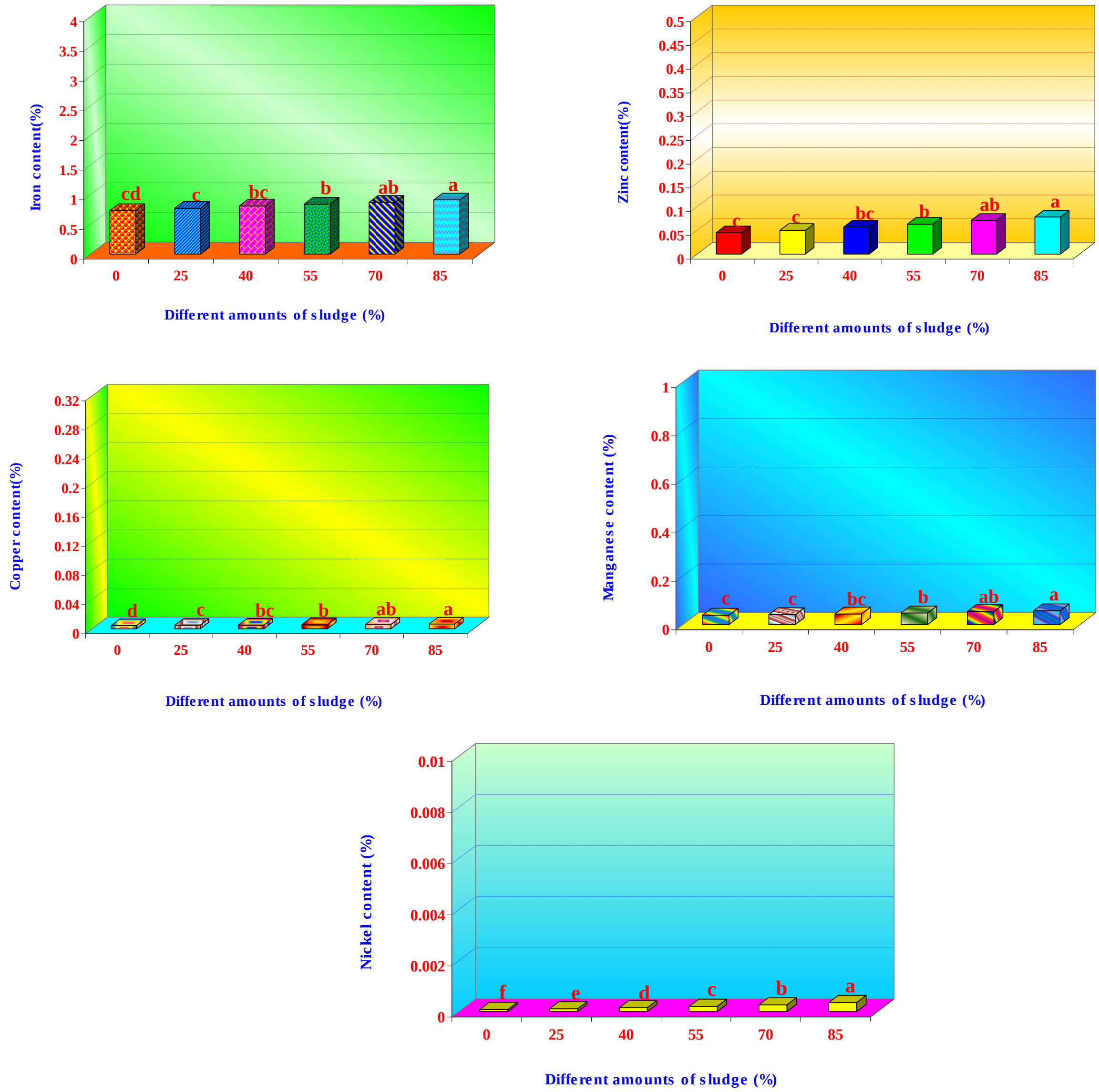

Fig. 3. Comparison of the amount of Iron (Fe), Zinc (Zn), Copper (Cu), Manganese (Mn), and Nickel (Ni) produced vermicompost for different amounts of sludge.

Conclusions

In general, the use of refinery sewage sludge up to 85% in the process of vermicompost production, increases the value of vermicompost produced in terms of macro elements (nitrogen, phosphorus, and potassium) and micro element (iron, zinc, copper, and manganese) for plants. However, the C/N ratio, which reflects organic decomposition and stability obtained during the composting process in treatment, 85% of sewage sludge decreased. According to this result, application of 70% of sewage sludge with 15% manure with 15% of bulking material is an optimal range for obtaining a biological fertilizer with high fertilizer value for agriculture and landscape. The amount of vermicompost manure produced in terms of macro nutrient and micro nutrients is optimally in terms of fertilizer use standards and richer than fertilizers used in agriculture.

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