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# Municipality Sewage Sludge Effects on Wheat Grain Yield and Nutrients Content

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**Abstract:** Land application of wastes and recycling nutrients through the soil-plant complex has been a commonly accepted method of disposal. To study the effects of sewage sludge on wheat chemical composition and yield, in the field plot that includes treatments control, 25, 50 and 100 tons of sludge per hectare (based on dry weight) the wheat (Back-cross Roshan cv) was cultivated. Statistical design was a randomized complete block design with three replications. Sludge treatment significantly increased the wheat biomass, 1000grain weight and grain yield. Sewage sludge contains organic matter and nutrients required by the plant, and by affecting the chemical, physical and biological soil properties, can increase crop yield. The use of more than 25 tons' sludge per hectare even in successive cultures is not recommended. Applying sludge caused significant increase the mean values of N and Fe in the wheat seed. Seed Cr, Co, Pb and Cd weren't in limit of atomic absorption system detection ( $\mu\text{g kg}^{-1}$ ).

**Keywords:** Sewage Sludge, Soil Fertility, Wheat, Yield, Nutrients

## INTRODUCTION

Land application of wastes and recycling nutrients through the soil-plant complex has been a commonly accepted method of disposal. Composting municipal solid waste when is done properly plays a role in organic matter supplement for agricultural land, revenue for the municipalities is an environments acceptable waste disposal (Higgin et al., 2003). Direct land application could save treatment costs and add organic matter and the needed nutrients to soils, especially in an arid environment where the soil are low in organic matter and high in lime content. The chemical properties of the sewage sludge widely fluctuate throughout the years. The sludge had an acidic pH, high EC, high micro and macro- nutrients, and low heavy metals content.

The use of waste to enhance soil fertility may lead to accumulation of heavy metals in soil and transfer these elements to plants. This situation generally occurs when the industrial sludge to be used (Pingh and Agrawal, 2008) or large quantities of organic fertilizers such as compost added to soil (Gandomkar et al., 2004). Adding a lot of compost leachate, sewage sludge, municipal solid waste compost (Gandomkar et al., 2004) can increase the soil salinity. The elimination of microelements deficiency by organic matter is due to the complex power of this material. Numerous reports eliminate of micronutrients deficiency by manure, poultry manure and sewage sludge is available (Pingh and Agrawal, 2008).

Low organic matter in arid region soils has caused organic compounds under different names, including sewage sludge, municipal solid waste compost and other organic waste, added to the soil. These compounds have material or useful elements such as carbon, phosphorus, nitrogen, potassium and other elements that are necessary for plant growth, but with harmful substances such as heavy metals (Cd, Pb, etc) can combine this polluted environment and cause the entry of these substances into food chains (Gandomkar et al., 2004).

In a study of heavy metals in soil treated with sewage sludge, leaching, and moved. As in the treatment of 100 tons of sludge per hectare, the available of cadmium more than 12 times of control, the available of zinc was 5.34 times of control, the available of lead was 7.3 times of control and the available copper was 3.42 times of control (Higgins, 2003). A study in a samples of sewage sludge showed  $121 \mu\text{g gr}^{-1}$  Pb and in other samples  $545\text{-}7432 \mu\text{g gr}^{-1}$  Pb, in USA has been reported (Higgins, 2003).

Mcintosh et al., reported the effects of sewage sludge on the root and aerial Pb and Cd content of fenugreek. The amount of Cd and Pb in all treatments was less than the norm but Pb absorbed higher than Cd. Comparison of manure, municipal solid waste compost and sewage sludge showed that sewage sludge is much richer than two other fertilizers, especially in terms of trace elements (Mcintosh et al., 2000; Mitchell et al., 2006). The use of sewage sludge can play a role in soil P releases. In a study of the cumulative amount of P released during a period of 1,560 hours (65 days) in control soils equal to  $0.55\text{-}6.1 \text{ mg kg}^{-1}$  and in soils treated with sewage sludge equal to  $1.3\text{-}15.9 \text{ mg kg}^{-1}$  (Higgins, 2003). The objectives of this research were to study (i)the effects of sludge application on yield, (ii)the concentration of macr-micro-nutrients and heavy metals in wheat leave and seed.

## Material and Methods

To study the effects of sewage sludge on wheat chemical composition and yield, in the field plot that includes treatments zero (control), 25, 50 and 100 tons of sludge per hectare (based on dry weight) the wheat (Back-cross Roshan cv) was cultivated. Statistical design was a randomized complete block design with three replications. The test region was located at(GPS) $51^{\circ} 49' 36.61$  E longitude and  $32^{\circ} 30' 36.61$ N latitude. The average altitude is 1545m above sea level. The soil in the study area in terms of type of land on the river alluvial terraces and the geomorphological unit formed and evolved on the first river-terrace of Zayandehrood river. The soil classification was (Clayey skeletal, carbonatic, thermic, typic calciargids, USDA, 2018). The soil texture was clay, pH was 7.5, ECe was  $2.1 \text{ dS m}^{-1}$ , organic matter content was 1. 2%, CEC was  $15 \text{ Cmol (+) kg}^{-1}$  soil, equivalent calcium carbonate was 45%.

According to the bioclimatic map of Iran (Emberge method) Kabootar-abad station located in arid cold climates. The average annual precipitation has been measured 142.4 mm. The average temperature fluctuation has been reported between 4 to  $37.1^{\circ}\text{C}$  over the years (Hemmat et al., 2010). The sewage sludge provided from Shahin-shahr sewage treatment plant. The way to refine this sewage was secondary aerated lagoons method. Sludge used outdoors and exposed to sunlight for a year. Sludge was added a month before planting into the soil. Due to the amount of nutrients in sludge and soil testing, fertilizer needs of wheat in the control plot was paid. The wheat biomass and grain yield were measured. Analysis of samples was done in the soil and plants laboratory of Esfahan agricultural research center. Sludge dry matter content by placing 10 gr of sludge in the oven (at $75^{\circ}\text{C}$ ) for 24 hours was determined. Total nitrogen was measured by Kjeldahl method (Sparks et al., 1996).

Plant samples digested in a mixture of sulfuric acid and salicylic acid method include wet ash were prepared.

Content of Ca, Mg, Fe, Mn, Zn, Cu, Pb, Ni, Cr, Cd in plant extracts by atomic absorption with oven graphics were measured in the laboratory of Esfahan university of technology, the accuracy of this method was in the range of micrograms. The resulting data were analyzed of variance using the softwares and the comparison of means was performed at the level of five percent using Duncan's multiple range test.

## Results and Discussion

The quality of irrigation water in terms of salinity ( $EC\ 3.5\ ds\ m^{-1}$ ) and acidity (pH 7.6) was with moderate limitations. The source of irrigation water was a mixture of ground water and the irrigation network of Zayandehrood river. The amount of water entering the plots was controlled by parshalflum. The amount of water used during the growth period was about seven thousand cubic meters per hectare.

### Biomass and grain yield of wheat

The effect of different amounts of sludge on the mean values of dry matter, are gathered in table 1. Effects of sludge treatment significantly increased the wheat biomass, 1000grain weight and grain yield. The significant increase in biological yield by application of sludge wasn't only due to nutrient elements of sludge, but may have been caused by sludge organic matter content, acidic pH, etc. Sewage sludge contains organic matter and nutrients required by the plant, and by affecting of the chemical, physical, and biological of soil, can increase crop yield. According to the survey results, these effects remain in the soil for at least two year. Mitchell et al., (2006) reported the positive effects of sewage sludge on wheat biological and grain yield.

**Table 1:** Mean values of wheat biological dry weight ( $t\ ha^{-1}$ ) \*

sludge rate	0	25	50	100
biomass	12.5D	20.5C	23.5B	26.5A
grain	5.2c	8.74B	9.4B	11.9A
1000grain weight(gr)	31.5C	36.5B	38.5AB	41A

\* In each row, numbers followed by the same letter are not significantly different ( $P < 0.05$ )

### The wheat leaves nutrient content

The mean values of some elements of wheat leaf are gathered in table 2. Elements Co, Pb, Cd were not in atomic absorption system detection limit ( $\mu g\ kg^{-1}$ ). Sludge application didn't significantly increased concentrations of leaf elements. This may be due to the dilution effects because of growth increase by sludge application.

**Table 2:** Mean values some of the wheat leaf elements\*

nut/ treat	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	%					$mg\ kg^{-1}$			
1	0.38	0.1	2.0	0.2	0.035	17.2	22.3	61.0	5.0
2	0.42	0.14	2.2	0.24	0.06	24.0	22.6	100.0	6.0
3	0.52	0.15	2.6	0.26	0.07	27.0	25.0	116.0	7.1
4	0.58	0.14	2.6	0.26	0.07	26.0	23.0	104.5	6.5

\*In each column the changes are not significantly different ( $P < 0.05$ )

### The root nutrient content

The mean values of some elements of the root are shown in (Table 3). Element Co, Pb and Cd were not in atomic absorption system detection limit ( $\mu\text{g kg}^{-1}$ ). Sludge application significantly increased the mean values of N, Ca, Zn, Mn, Fe and Cu content of the root. In addition to increasing the amount of these elements by adding sludge to soil, development of the plant roots can increase these nutrients uptake. Also the acid in sludge can increase the solubility of elements and increasing their uptake by the roots (Chaney, 2004; Mcintosh et al., 2000). Hemmat et al., reported the increasing of organic matter and soil porosity by using of sewage sludge and appropriate rizhospher for the root to develop.

**Table 3:** Mean values some of the wheat root elements \*

nut/treat	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	%					$\text{mg kg}^{-1}$			
1	0.49 B	0.16	0.12	0.59 A	0.11	29.0 B	47.0 B	530.6C	11.3B
2	0.64 B	0.20	0.16	0.71 B	0.14	31.2 B	55.5 B	804.2B	9.7B
3	0.80 A	0.25	0.17	0.81 A	0.17	40.2 A	65.0 A	1058.0A	17.4A
4	0.73 A	0.25	0.19	0.81 A	0.17	41.0 A	64.4 A	1032.0A	16.0A

\* In each column, numbers followed by the same or no letter are not significantly different ( $P < 0.05$ )

### The wheat seed nutrient content

Applying sludge caused significant increase the mean values of N and Fe in the wheat seed (Table 4). Cr, Co, Pb, Cd in seed were not in atomic absorption system detection limit ( $\mu\text{g kg}^{-1}$ ). Thereby increasing its nutritional value of seeds will increase the nutritional value of it (fortification). Wheat grain formation and filling are critical processes in the wheat grain production. One of the main problems of wheat fields is the lack of complete germination. Bouriou et al., (2018) reported significant sewage sludge effect on increasing nutrients uptake in plant tissue.

**Table 4:** Mean values some of the wheat seed elements \*

nut/treat	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu
	0%					$\text{mg kg}^{-1}$			
1	2.0B	0.38	0.52	0.15	0.14	47.5	51.0	79.0C	8.6
2	2.4A	0.44	0.56	0.17	0.14	50.0	53.2	138.5B	10.6
3	2.5A	0.48	0.68	0.23	0.16	63.1	61.0	296.0A	12.3
4	2.5A	0.47	0.58	0.23	0.17	63.0	59.2	285.3A	12.4

\* In each column, numbers followed by the same or no letter are not significantly different ( $P < 0.05$ )

### Conclusion

Effects of sludge treatment significantly increased the wheat biomass, 1000grain weight and grain yield ( $p < 5\%$ ). The tested sludge contains considerable quantities of plant nutrients which can be useful in soil fertility and crop needs. The concentration of trace elements and heavy metals in used sludge, according to EPA, 1995(4) limits are lower than limited level and can be used in agricultural land. The soil of the testing location is calcareous (45%), clayey (38%) and has a high buffering capacity to absorb and stabilize heavy elements. Alkaline pH of soil (7.7) can also to deposit and cause non-absorbable metal elements. The above characteristics can prevent the absorption of heavy metals by plants are over.

The effects of sludge application significantly increases ( $p < 5\%$ ) soil, OC, EC, and soil available N, P, K, Zn, Mn and Fe. Between the heavy metals only available Co was increased significantly but the increase of Co in compare with the standard was not toxicant to plant. The effect of sludge

treatments(25tha<sup>-1</sup>) also increased the biological yield of wheat significantly. Due to the soil physico-chemical characteristics, soil salinity and heavy metals accumulation, 100 t ha<sup>-1</sup> sludge had negative effects on wheat growth. Thus, the use of sludge more than 25 tha<sup>-1</sup> even in continuous cultivation is not recommended. According to this study sewage sludge had a good value as a fertilizer, and the purification its from human pathogens can be used it as an organic fertilizer on agricultural land limitedly.

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