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Effect of direct application of different doses of sewage sludge with different level of phosphorus on soil micronutrients under green gram (*Vigna radiata* L.)

Bhagyashree Kesherwani and Tarence Thomas

Abstract

A field experiment was conducted to study the effect of direct application of different concentration of sewage sludge with different level of phosphorus on soil micronutrients under green gram (*Vigna radiata* L.) on a sandy loam soil during Kharif seasons of 2018 at the nursery of forestry, Department of Environmental Sciences & NRM in SHUATS, Prayagraj, (U. P.). Nineteen treatments were employed using three different areas STPs sewage sludge (SS) they are Naini STPs (A1), Rajapur STPs (A2) and Pritamnagar STPs (A3) of two different doses of SS (10 t/ha and 15 t/ha) with two-level of phosphorus (100% and 50%) to find the accumulation of micronutrient in soil depths. Experiment results showed a significant increase in the accumulation of micronutrient (Fe, Cu, Zn, and Mn) by 89.49%, 71.47, 85.42% and 57.57% respectively in treatment T2 as compared to control in soil (0-15 cm) depths. After application of phosphorus with SS, the accumulation of micronutrient highly increase as compared to direct use of SS. Cu and Zn increase in treatment T8, T12 and T16 in both soil depths as compared to treatment T2, T4 and T6. Naini STPs recorded low pH, which increase the solubility of macro-micro nutrient in the soil and phosphorus application increased the accumulation of Cu and Zn in soil depths which lead to improving soil nutrient status and also decreases the uptake of higher amount of nutrient to the plant parts which gives us growth and yield production to the crop.

Keywords: Sewage sludge, phosphorus, accumulation, micronutrient and doses

Introduction

With the rapid increase in human water consumption, continually more sewage treatment plants are being constructed, resulting in a rapid increase in the production of sewage sludge (SS). Traditional disposal methods of SS include incineration, sanitary landfill, land utilization, construction material utilization and anaerobic digestion for methane recycling (Chen *et al*., 2014) [5]. SS is a complex substance composed of organic debris, inorganic particles, pathogens, colloid sludge, and moisture. It also contains heavy metals (HMs) and other poisonous and pernicious substances. Without proper treatment, it may pose a potential threat to the environment and human health. Therefore, rational and environmentally friendly approaches are urgently needed to solve these problems. Present time phosphorus fertilizers are used to increases the quality and quantity of production of the crop with a higher amount is used in the agriculture field. The crop responds favorably to the application of fertilizer phosphorus (Shah *et al.*, 1994) [14]. Mungbean is one of the major rainy (Kharif) season pulse crop of India. The yield and nutritional quality of mung bean are greatly influenced by the application of nutrient elements along with organic manures. Legume crops mung bean (*Vigna radiate* L.) has the potential to fix atmospheric nitrogen through its root nodules, which requires phosphorus for their proper growth and development. Phosphorus level increased the accumulation of Cu and Zn in the soil which decreases the availability to the plant part which was behaved as heavy metal in higher concentration shows toxic to crop. Cu and Zn in large amounts show the negative effect on the growth of the plant. If the use of phosphorus with sewage sludge increased the accumulation of Cu and Zn in soil depth then the concentration of these elements reduces in plant parts. Therefore, the purposes of this study are to investigate the influence of sewage sludge with phosphorus application on soil physicochemical properties including pH, micronutrient (Fe, Cu, Mg and Zn) of post-harvest soil.

Materials and Methods

Study areas and sample collection

The field experiment was conducted to evaluate the effect of sewage sludge on soil physicochemical properties included micronutrient was observed in different STPs sewage sludge at nursery of forestry, Department of Environmental Sciences & NRM in SHUATS, Prayagraj, (U.P.). Mean ambient temperature varied from 20°C to 43°C during the experimentation period from March to May 2018. Maximum and minimum relative humidity varied from 40.8 to 73.75% and from 20.2 to 33.0%, respectively. Post-harvest soil was collected from the field at the depth of 0-15cm and 15-30 cm. Sewage sludge was collected from different STPs of Prayagraj, district, U.P. they are Pikh Patti near Old Bridge Naini (STP A_1), Rajapur (STP A_2), Kodra, Pritam Nagar (STP A_3).

Experimental designs

Experiment second was set up in randomized block design with nineteen treatments and three replications, (twenty one plots of 2m × 2m size) in winter season at nursery of forestry, SHUATS, Prayagraj. Collected sewage sludge from different STPs, was air dried and grounded uniformly to get homogenous mass and mixed uniformly with the help of rototiller according to their treatment combinations (mixed before sowing at @ of 10t ha^{-1} and 15t ha^{-1}, respectively in each plots). Treatment were designed T_0 (Control, only soil), T_1 (A_1+10t ha^{-1} SS), T_2 (A_1+15t ha^{-1}SS), T_3 (A_2+10t ha^{-1}SS), T_4 (A_2+15t ha^{-1}SS), T_5 (A_3+10t ha^{-1}SS), T_6 (A_3+15t ha^{-1}SS), T7 **(**A_1 +10 t/h^{-1} SS +100% P), T8 (A_1 +15 t/h^{-1} SS +100% P), T9 **(**A_1 +10 t/h^{-1} SS +50% P), T10(A_1 +15 t/h^{-1} SS +50% P), T11(A_2 +10t/h^{-1} SS +100% P), T12(A_2 +15 t/h^{-1} SS +100% P), T13 (A_2+10 t/h^{-1} SS +50% P), T14(A_2 +15 t/h^{-1} SS +50% P), T15 (A_3 +10 t/h^{-1} SS +100% P), T16(A_3 +15 t/h^{-1} SS +100% P), T17(A_3 +10 t/h^{-1} SS +50% P), T18 (A_3 +15 t/h^{-1} SS +50% P), After maintaining identical moisture levels in each plot, green gram seeds were sown manually and plant spacing was row to row 30 cm and plant to plant 10 cm. Post-harvest soil samples were collected from experimental field at the depth 0-15cm and 15-30 cm layer Soil samples were dried and passed through a 2-mm sieve. The soil samples were analyses for parameters as described for initial characterization.

Soil and sewage sludge analysis

Evaluate the initial physiochemical properties of the soil and as well as three sites of STPs sewage sludge. Samples were air-dried, crushed, passed through a sieve of 2 mm mesh size and then stored separately for further analyses. The pH of samples was measured with the help of pH meter and electrical conductivity (EC) by conductivity meter. For organic C (%) in the soil and sewage sludge were analysed from wet oxidation methods (*Walkley and Black* 1947) [18] and analyses of micronutrients (Fe, Cu, Mn and Zn) acid digestion method was followed by using flame Atomic Absorption Spectrophotometer (Perkin Elmer, A. Analyst 400) on dry weight basis (*Allen et al.*, 1986) [19].

Result

Initial physico-chemical properties status in sewage sludge and soil

The initial analysis of physico-chemical properties (pH, EC, OC%, and micronutrients Zn Cu Fe Mn) of soil & different area of STPs sewage sludge was given in (Table 1). The different SS parameters were significantly varied and recorded slightly acidic pH (ranged from 5.9 to 6.4) with higher EC (ranged from 1.08 mS cm^{-1} to 1.19 mS cm^{-1}) however pH was recorded lowest with higher level of EC, Organic C % and available micronutrients (Fe, Cu, Mn, Zn) in all STPs sewage sludge as compared to control soil. The different STPs sludge used for this study contains 8.20 to 14.03 mg kg^{-1} Fe, 29.2 to 226 mg kg^{-1} Cu, 88.88 to 226 mg kg^{-1} Mn and 25 to 114.3 mg kg^{-1} Zn respectively however permissible levels (*Council of the European Communities* 1986) of these metals in agricultural soil are 2500 mg kg^{-1} Zn, 1000 mg kg^{-1} Cu, respectively. All micronutrients showed under permissible limit.

Table 1: Chemical properties of soil and different STPs sewage sludge of Prayagraj, district.

Different STPs (sewage sludge)		pH (1:2)	EC (mS cm^{-1})	Organic C (%)	Fe (gm kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})
Control Soil		7.2	0.34	0.40	5.59	8.74	23.26	89.33
Naini	STP (A_1)	5.9	1.08	8.50	13.26	226.00	114.33	155.66
Rajapur	STP (A_2)	6.0	1.78	12.41	8.20	118.33	25.60	88.88
Pritam nagar	STP (A_3)	6.4	1.19	6.68	14.03	29.26	37.79	266.00
F- test		S	S	S	S	S	S	S
S. Ed. (±)		0.08	0.063	0.236	3.859	3.228	155.23	2.661
C. D. (P = 0.05)		0.19	0.133	0.500	8.182	6.844	329.08	5.640
C.V.		1.51	0.464	0.237	0.369	0.174	0.124	0.473

STP (sewage treatment plant), Different STPs area (A_1- Naini, A_2- Rajapur, A_3 – Pritamnagar).
Mean ± Standard error (n=3).different level of each parameter show a singnificant difference at (P<0.05).

Effect of direct application of different doses of sewage sludge on soil micronutrients

In the present study three different area of STPs sewage sludge was taken for the quality test with the use of the different level of phosphorus to determine the accumulation of micronutrient in different soil depths. Sewage sludge increased the micronutrient concentration in all the treatment in both soil depths. The result is shown in (Table 2) that all the treatment shows significant different at both depths of soil (0-15 & 15-30 cm). higher doses of SS (15 t/ha) accumulated more micronutrient as compare to low doses of SS 10 t/ha in all treatments. Initial reading found that low pH recorded in Naini STPs (A1) which also shows the impact on pH decreased in treatment T1 and T2 in soil depth as compare to Rajapur (A2) and Pritamnagar (A3). Low pH increased the solubility of micro-nutrient concentrations in soil. Fe, Cu, Zn and Mn increased in treatment T2 (A1 + 15t/ha) by 89.49%, 71.47, 85.42% and 57.57% respectively as compared to control in the top layer of soil (0-15 cm). Fe range from (4.47 to 13.23 gm /kg), Cu (13.2 to 29.8 mg/kg), Zn (20.7 to 98.8 mg/kg), Mn (60.2 to 99.7 mg/kg) as compare to control 1.39, 8.5, 14.40 and 42.3 respectively in 0-15 cm soil. Same result also observed in 15-30 cm soil depths, higher doses of SS (15 t/ ha) increased the micronutrient in treatment T2 (A1 + 15t/h) Fe, Cu, Zn and Mn increase by 90.65%, 66.23%, 75.90% and 59.47% respectively as compare to control in 15-30cm soil depths. Depth wise micronutrient accumulation decreases as shown in (Fig 1, 2, 3, 4).

Effect of different doses of sewage sludge application with different level phosphorus

Higher doses of SS 15 t/ha with 100% phosphorus in treatment T8, T12 and T16 increased the accumulation of Cu and Zn in both soil depths as compared to treatment T2, T4 and T6 (Table 2). Fe and Mn no such increment was recorded by the application of phosphorus fertilizer as compared to the direct application of SS in different soil depth. In this experiment concentration of micronutrients (Fe, Cu, Zn and Mn) shows higher in top layer soil (0-15 cm) and slightly different observed in 15-30 cm as compare to all treatment, result shown in Fig 1, 2, 3 and 4.

Table 2: Effect of direct application of different doses of sewage sludge with different level of phosphorus on soil micronutrient accumulated in two depths.

Treatment	0-15 cm					15-30 cm				
	pH (1:2)	Fe(gm kg1)	Cu(mg kg1)	Zn(mg kg1)	Mn(mg kg1)	pH (1:2)	Fe(gm kg1)	Cu(mg kg1)	Zn(mg kg1)	Mn(mg kg1)
	Effect of direct application of different doses of sewage sludge									
T0 (Control) soil	7.56	1.39	8.5	14.40	42.3	7.51	1.22	7.9	19.4	40
T1 ($A_1 S_1 P_0$)	6.9	11.3	23	83.50	89.5	7.15	11.1	22.9	80.5	87.6
T2 ($A_1 S_2 P_0$)	6.84	13.1	29.8	106.8	99.7	7.04	13.16	23.4	97.8	98.7
T3 ($A_2 S_1 P_0$)	7.22	12.46	19.4	55.5	74.25	7.25	12.08	18.5	52.7	67.7
T4 ($A_2 S_2 P_0$)	7.75	13.23	20.2	59.8	75.62	7.52	13.06	19.95	55.3	70.6
T5 ($A_3 S_1 P_0$)	7.91	5.35	17.8	31.3	83.4	7.85	5.16	15.6	30.8	82.9
T6 ($A_3 S_2 P_0$)	7.74	7.19	19.5	36.9	92.5	7.69	7.03	18.1	34.3	90.3
	Effect on different doses of sewage sludge application with different level of phosphorus									
T7 ($A_1 S_1 P_1$)	7.16	12.5	20	73.4	71.42	7.05	12.1	17.4	72.2	73.9
T8 ($A_1 S_2 P_1$)	7.15	12.11	30.8	99.2	73.42	7.07	11.23	25.4	98.6	70.9
T9 (A1 $S_1 P_2$)	7.23	11.12	18.05	54.8	60.29	7.15	11.05	14.3	53.3	61.7
T10 ($A_1 S_2 P_2$)	7.24	11.18	18.6	56.4	62.5	7.22	11.12	14.1	55.7	60.3
T11 ($A_2 S_1 P_1$)	7.62	12.45	18.1	39.9	75.6	7.95	12.05	18.1	46.1	74.2
T12 ($A_2 S_2 P_1$)	7.57	12.81	26.7	58.2	74.3	7.71	12.54	21.3	56.9	73.5
T13 ($A_2 S_1 P_2$)	7.44	12.38	15.3	20.7	73.8	7. 78	12.06	13.5	25.5	72.1
T14 ($A_2 S_2 P_2$)	7.6	12.81	16.3	32.9	73.5	7. 83	11.2	12.4	20.1	72.4
T15 ($A_3 S_1 P_1$)	7.65	8.53	17.4	30.6	88.72	7.81	6.11	15.6	35.8	86.1
T16 ($A_3 S_2 P_1$)	7.86	7.1	20.5	37.4	89.3	7.93	7	19.6	36.4	87.7
T17 ($A_3 S_1 P_2$)	7.4	4.47	16.4	29.9	72.6	7.67	4.31	11.3	28.6	71.3
T18 ($A_3 S_2 P_2$)	7.71	4.61	13.2	31.7	75.5	7.72	4.58	14.9	27.3	74.4
F – test	S	S	S	S	S	NS	S	S	S	S
S. Ed. (±)	0.006	0.03	0.07	0.02	0.02	1.17	0.03	0.07	0.08	0.13
C. D. at 5%	0.013	0.07	0.14	0.04	0.04		0.07	0.14	0.15	0.27

Different STPs area (A_1- Naini, A_2- Rajapur, A_3 – Pritamnagar), Sewage sludge (S_1 = 10 t/ ha, S_2 = 15 t/ ha), Phosphorous (P0 = no phosphorus, P_1 = 100%, P_2 = 50%). Mean ± Standard error (n=3). Different level of each parameter shows a significant and non-significant value difference at (*P*<0.05).Micronutrient doses limit in the soil established by (Council of the European Union, 1986) for agricultural soils, Cu 50-140mg/kg, Zn 150-300mg/kg,

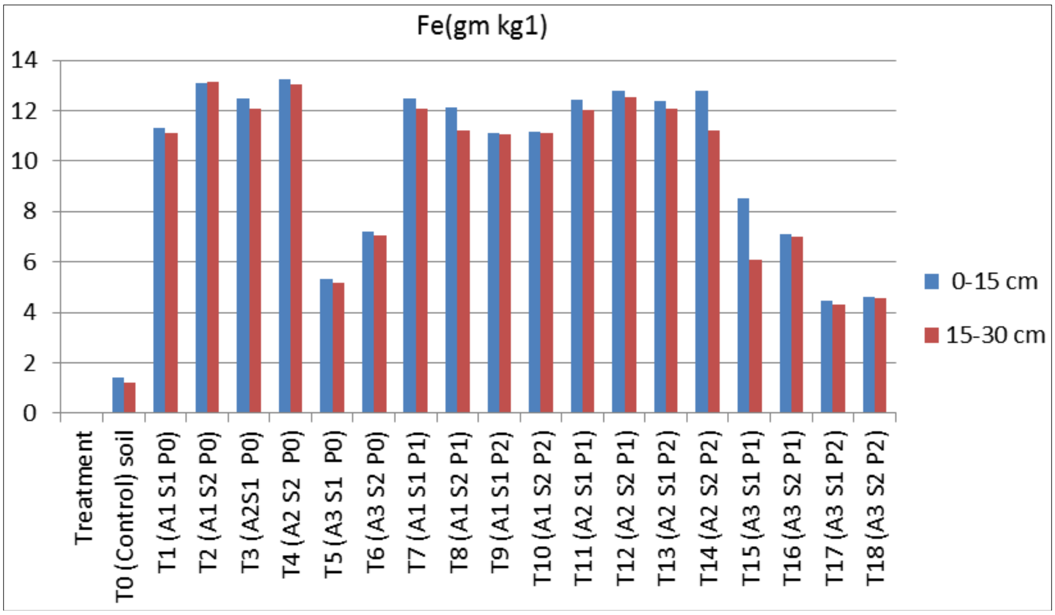

Fig 1: Effect of direct application of different doses of sewage sludge with different level of phosphorus on accumulated of Fe on different soil depths.

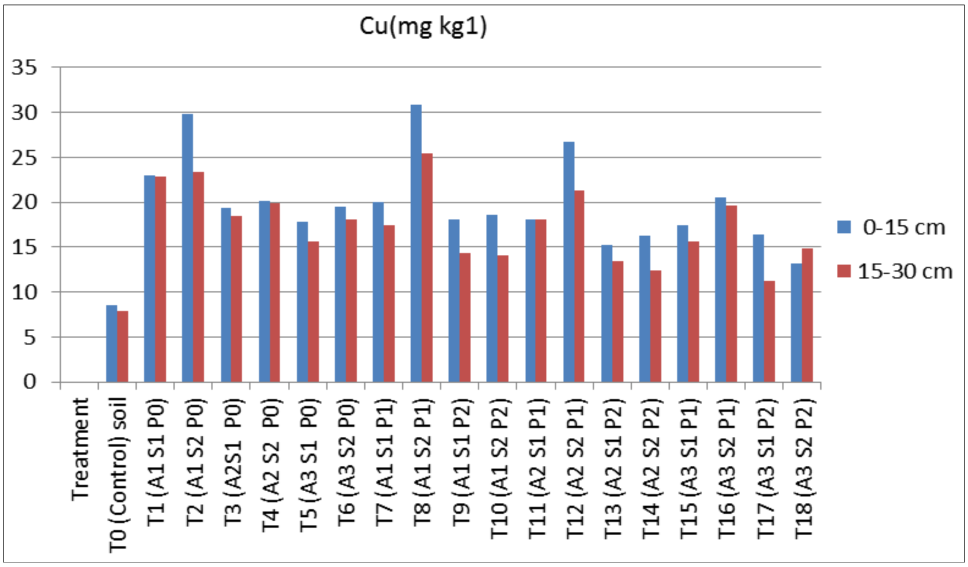

Fig 2: Effect of direct application of different doses of sewage sludge with different level of phosphorus on accumulated of Cu on different soil depths.

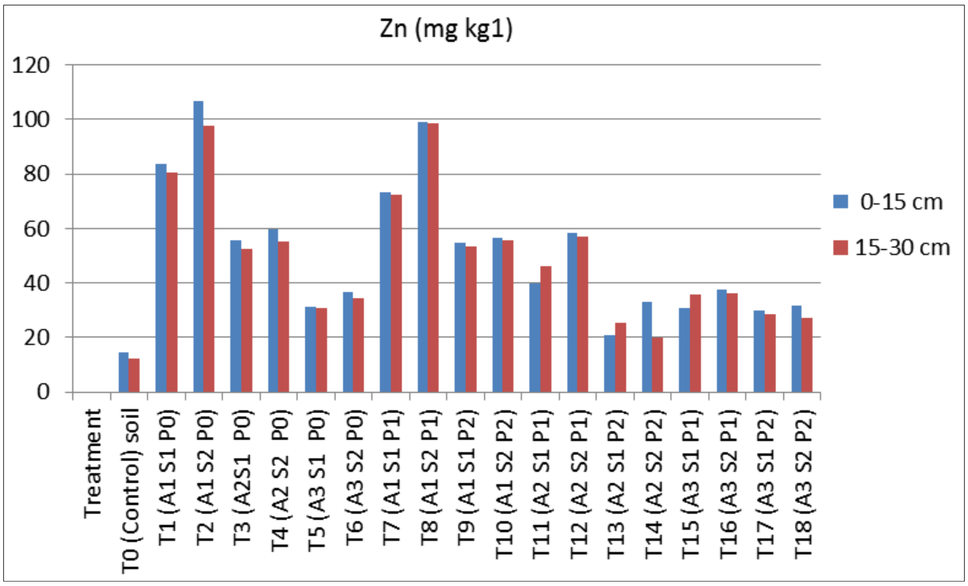

Fig 3: Effect of direct application of different doses of sewage sludge with different level of phosphorus on accumulated of Zn on different soil depths.

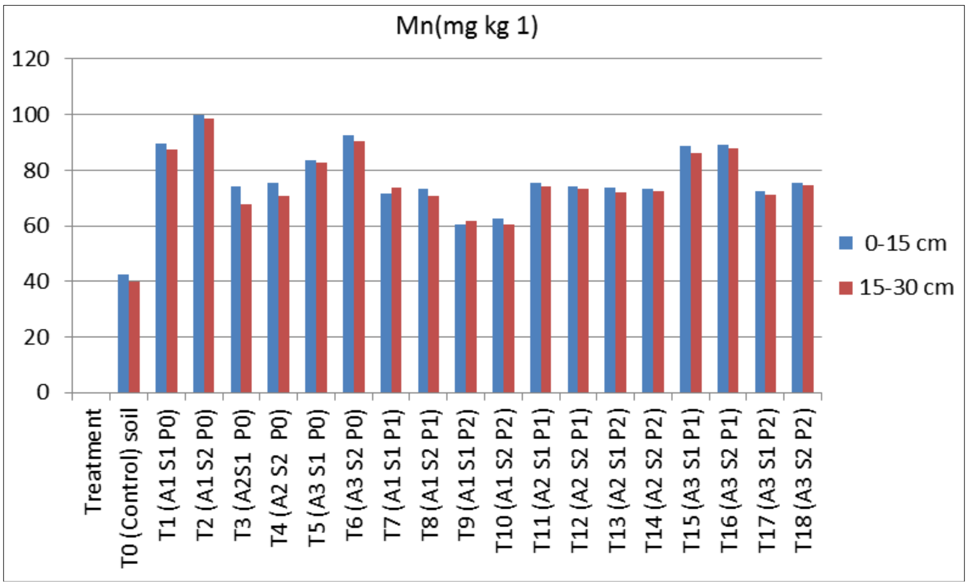

Fig 4: Effect of direct application of different doses of sewage sludge with different level of phosphorus on accumulated of Mn on different soil depths.

Discussion

From the obtained results, the characteristics of different STPs sewage sludge, such as pH, EC, Organic C% and micronutrient content were in an acceptable range and favorable for subsequent plant growth. Additional fertility characteristics, such as different Phosphorus levels were also fairly consistent. The total concentrations of micronutrients (Fe, Cu, Zn and Mn) sewage sludge were found low doses, compared with the current limits established by the EU and the USEPA for sewage sludge applied to agricultural soils. The results also showed the lowest pH observed in Naini STPs (A1) sewage sludge with higher EC, OC% and micronutrient (Fe>Cu>Mn>Zn) as compare to other STPs which was Rajapur STPs(A1) and Pritamnagar STPs(A3). All of three STPs Pritamnagar (A3) shows less polluted compares to others. Initial finding of SS showed decreased in pH value with increased concentration in EC, Organic C% and micronutrient (Fe, Cu, Zn and Mn) similar findings has been also recorded by many others, (Moreno *et al*., 1997) [11] found that release of humic acid due to biodegradation of organic carbon rich sewage sludge may be ascribed to low soil pH at different doses of sewage sludge. (Sharma *et al*., 2006) [15] reported that due to the high levels of heavy metal concentrations in the wastewater of DSTP influenced the pH and EC.

Micronutrients content in different soil depth

In present study observed that the direct application of SS (15t /ha) at higher doses increased the amount of micronutrient in both soil depths (0-15 and 15-30cm). Similar result were observed by (Latare, A.M 2014) that significant increase in content of micronutrient at higher doses of sludge application (30 and 40 t/ha) both as direct and residual effect on rice and wheat crops increased availability of micronutrients with the direct application of SS could be interpreted as it serves a source of micronutrient and also by way of its chelating action. The concentrations of Zn, Cu, Pb, and Ni in the post-harvestt soils were generally higher than that of the soil, biochar, and sludge; partly because post-harvest samples were collected from the amended top 15-cm layer rather than the entire experimental pot. The high clayey content (60–64%) of the experimental soil (Mapanda *et al*., 2012) [10]. In this study, Naini STPs SS in treatment T2 (A1 S2 P0) observed higher accumulation of micronutrient as compare to other STPs SS. Naini STP has low pH which was increased the solubility of macro and micronutrient in soil depth. All micronutrient (Fe, Cu, Zn and Mn) showed increased accumulation in both soil depths due to low pH and higher doses of SS (15 t/ha). A similar study also reveals by (Dede *et al*., 2013) that by the addition of sewage sludge, low pH increase the solubility of macro and micronutrient in soil depth and Cu and Zn observed most mobile micronutrient in soil depth. Many authors have argued that an alkaline pH would prompt a low solubility of macro and microelements, whereas a lower soil pH would increase the solubility of elements and, hence, their movement in soil (Aitazaz *et al*., 2011; Ozdemir 2005) [1, 6]. The effects of pH on these fractions were not surprising, as it is well-known that the occupation of H+ on the exchange sites of the mineral surfaces leads to a decrease in the bonding of elements to soil particles, and thus, to increased solubility of the elements (Forsberg and Ledin, 2006) [8]. Similarly, sewage sludge application increased soil DTPA-extractable element concentrations, especially those of Zn and Cu, at the 100- and 200ton application rates. Sludge application of 100 tons increased the soluble concentration of Zn up to 7%. Besides, sludge addition increased the soluble concentration of Cu up to 11% at the 200 t/ha application rate. Similar results were obtained by (Antolin *et al.,* 2005, and Forsberg and Ledin, 2006) [3, 8].

In this experiment different level of phosphorus (100 and 50%) was taken with different doses of sewage sludge to fine and increases the accumulation of heavy metals and micronutrient in different soil depth which was present in sewage sludge. The result was observed that in treatment T8, T12 and T16 (A1S2P1, A2S2P1 and A3S2P1) which was different area STPs sewage sludge with higher doses of SS(15 t/ha) and 100% phosphorus increased the accumulation of Cu and Zn content in top layer soil(0-15 cm) depths as compare to direct application of sewage sludge in treatment T2, T4 and T6(A1S2, A2S2 and A3S2) phosphorus level increased the accumulation of Cu and Zn in soil which decreases the availability to the plant part which was contaminated by heavy metal. Cu and Zn in large amount behave like a toxic effect on the growth of the plant. If the use of phosphorus with sewage sludge increased the accumulation of Cu and Zn in soil depth then the concentration of these elements reduces in plant parts. The similar finding also observed by (Thomas *et al.,* 2012) [16] that different levels of phosphate fertilizer application Zn, Cu and Cd shows an increase in the soil concentration with an increase in levels of phosphate fertilizer applied. The increase in the concentration of the heavy metals in the soil after the experiment shows that phosphate fertilizers contribute greatly to heavy metal content in soils. This is consistent with the findings of (Oyedele *et al.,* 2006) [12]. Cu, Zn, Cd and Pb show a high concentration in the soil after the experiment at all treatment levels. Cu and Zn had over 400% increment, (Alloway, 1990) [2] reported that the soil is an important sink for heavy metals. Zinc concentration increased with an increase in fertilizer level to further confirm that Zn is mobile. This supports the assertions of (Vanek *et al.,* 2005) [17] that Zinc and Cadmium are highly mobile in the soil. The fairly high uptake of Cu, Zn and Cd by the plant roots and stems under 0kg/ha phosphate fertilizer shows that Amaranthus caudatus has the potential of being used to clean up heavy metal contaminated soils and that only uncontaminated soils should be used to produce the vegetable.

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References

1. Aitazaz A, Farooque AA, Zaman QU, Madani A, Abbas F, Percival DC *et al*. Ecological impacts of the Nviro biosolids land-application for wild blueberry (*Vaccinium angustifolium* Ait) production in Nova Scotia. Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes. 2011; 46(4):366-379.
2. Alloway BJ. Toxic Metals in soil-plant systems. John Wiley and Sons, Chichester, 1990.
3. Antolin MC, Pascual I, Garcia C, Polo A, Sanchez-Diaz M. Growth, yield and solute content of barley in soils treated with sewage sludge under semiarid Mediterranean conditions. Field Crops Research. 2005; 94:224-237.
4. CEC. (Council of the European Communities): Council Directive of protection of environment and in particular

of the soil, when sewage sludge is used in agriculture (86/278/EEC). Off. J Eur. Comm. 1986, No. L181/6-12

5. Chen T, Zhang Y, Wang H, Lu W, Zhou Z, Zhang Y *et al*. Influence of pyrolysis temperature on characteristics and heavy metal adsorptive performance of biochar derived from municipal sewage sludge. Bioresour. Technol. 2014; 164:47-54.
6. Dede G, Ozdemir S, Dede HO, Altundag H, Dundar SM, Kiziloglu TF. Effects of sewage sludge on nutrient availability for kiwi fruits under high pH soil conditions. Fresenius Environmental Bulletin PSP. 2015, 24:5a.
7. Epstein EL. Application of Sewage Sludge and Biosolids, Lewis Publishers, 2002.
8. Forsberg LS, Ledin S. Effects of sewage sludge on pH and plant availability of metals in oxidising sulphide mine tailings. Science of the Total Environmen. 2006; 358:21-35.
9. Latare AM, Kumar O, Singh SK, Gupta A. Direct and residual effect of sewage sludge on yield, heavy metals content and soil fertility under rice-wheat system. Ecol. Eng. 2014; 69:17-24.
10. Mapanda F, Wuta M, Nyamangara J, Rees RM. Nitrogen leaching and indirect nitrous oxide emissions from fertilized croplands in Zimbabwe. Nutrient Cycling in Agroecosystems. 2012; 94:85-96.
11. Moreno JL, Garcia C, Hernandez T, Ayuso M. Application of composted sewage sludges contaminated with heavy metals to an agricultural soil effect on lettuce growth. Soil Sci. Plant Nutr. 1997; 4:565-573.
12. Oyedele DJ, Asonugho C, Awotoye OO. Heavy metals in soil and accumulation by edible vegetables after phosphate fertilizer application. Electronic Journal of Environmental, Agricultural and Food Chemistry. 2006; 5(4):1446-1453.
13. Özdemir S. Effects of municipal solid waste (MSW) compost on nodulation, plant growth and mineral composition of chickpea in marginal land. Fresenius Environmental Bulletin. 2005; 14(7):599-604.
14. Shah SK, Sharma GL, Vyas AK. Growth parameters biomass production under nutrient uptake by blackgram (*Phaseolus mungo*) as influenced by phosphorus, potassium and plant growth regulators. Indian J Agron. 1994; 39:481-483.
15. Sharma RK, Agrawal M, Marshall FM. Heavy metal contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull. Environ. Contam. Toxicol. 2006; 77:312-318.
16. Thomas EY, Omueti JAI, Ogundayomi O. The effect of phosphorus fertilizer on heavy metal in soil and *Amaranthus caudatus*. Agriculture and Biology Journal of North America. 2012; 3-4:145-149.
17. Vanek A, Boruvka L, Drábek O, Mihaljevič M, Komáre. Mobility of Lead, Zinc and Cadmium in alluvial soils heavily polluted by smeling indusry. Plant Soil Environment. 2005; 51(7):316-321.
18. Walkley A, Black CA. Estimation of organic carbon by chromic acid and titration method. Soil Sci. 1934; 37:28-29.
19. Allen SE, Grimshaw HM, Rowland AP. Chemical analysis. In: Moore, P.D., Chapman, S.B. (Eds.), Methods in Plant Ecology. Blackwell Scientific Publication, Oxford, London, 1986, 285-344.