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Impact of Use of Press Mud as Fertilizer on the Concentration of Copper and Nickel in the Soil and Livestock Oat Fodder

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Abstract.- Present study was carried out to determine the effect of different doses of press mud on Cu and Ni concentrations of oat fodder (*Avena sativa* L.) in Sargodha, Pakistan. The Cu concentration increased with adding press mud to the soil of forages though not significantly. The highest value (1.53 mg/kg) of Cu was found in soil samples that received 1200 kg ha^{-1} press mud however, it was not significant. The value of Ni soil concentration ranged from 0.55 to 1.76 mg/kg while that of Cu from 0.83 to 1.47 mg/kg and 0.88 to 1.08 mg/kg for early and late harvested leaves, respectively. The Cu concentrations of soil were numerically greater in the treatments receiving press mud (as full dose) compared to the control, while it was numerically lower in the treatments receiving press mud (as half dose). Highest Ni contents were observed for the early leaves of 3rd treatment, while for the late leaves for the 6th interval. Ni concentration ranges in early leaves was from 0.33 to 0.94 mg/kg and 0.27 to 1.1 mg/kg in late leaves. Concentration of Cu and Ni in soil and plant samples from all the treatments was found to be below the toxic level except late leaves which had Ni in toxic range. Consequently, feeding ruminants with this fodder would have no potential threat. The concentration of the heavy metals does not go above the suggested reference standards. In addition, it is suggested that press mud fertilizer does not show heavy metal poisonous squander, in addition, a first-rate resource of soil elements and organic stuff to the agricultural land.

Key words: Press mud, copper, nickel, oat composts, ruminants.

INTRODUCTION

Essentiality of metals for some elevated plants and animals is now well documented; however, its elevated concentration is lethal for plants, animals and human beings. Increasing guideline of the flaming of crop residues and handing out by-products has inspired curiosity in the utilization of composted agricultural processing by-products as soil amendments and horticultural growing media (Mathews and Thurkins, 2006). Substantial improvements in soils amended with composts through additional organic matter appears to be the maximum possible advantage as a fractional fertilizer alternate for N, P and K. Phytoavailability of Ni in soils is proscribed by extra than a only some soil and plant factors. Phytoavailability of metals can be decreased by *in-situ* immobilization of heavy metals with the soil amendments. However, organic amendments might be used because these get better soil physical and chemical properties and helps augmentation of plants on unhygienic soils.

Press mud is a solid waste by-product of sugar-mill and about 3% produced from total quantity of cane crushed. Press mud is a prosperous cause of organic carbon, NPK and other micronutrients (Rakkiyapan *et al*., 2001). Several studies have been conducted on Press mud for its suitability to use in agriculture and for energy production (Partha and Sivasubramanian, 2006). Inclusion of organic materials such as crop residues, green-manure crops, press mud, and water hyacinth have been advocated to improve soil organic matter, structure, water infiltration, and decrease pH (Ibrahim *et al*., 2012). Heavy metals are able to form insoluble complex compounds with soil organic matter and micro-elements work as cofactor (Raza *et al*., 2013; Rehman *et al*., 2013).

Growing parameter of the flaming of crop residues and doling out by-products has enthused curiosity in the consumption of composted farming dispensation by-products as soil amendments and horticultural increasing media. Composting is an efficient technique for altering organic concrete ravage into fertilizer that is prosperous of nutrients.

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Numerous types of squander, such as straw, leaves, sludge, manure, faeces and so on, are suitable for composting. Because compost is biologically additional well-suited than chemical fertilizers for soils and plants, composting has develop into a favorite option for treating organic solid squander. Physical improvements in soils amended with composts through additional organic matter appear to be the maximum prospective advantage as a fractional fertilizer alternate for N, P and K.

Though, the extensive supply of heavy metals in soil, water and atmosphere, create the unprocessed resources for compost achievable sources of heavy metal contamination. Their accessible formations can be distorted by materials such as lime, which are added to compost materials. After their prologue into the soil, the mobility or bioavailability of heavy metals in manure can be changed by numerous factors arising concurrently from soil, plants or precipitation.

Main aim of this study is to provide the plants with nutrients according to their necessities in order to take full advantage of plant acquiesce, by using a low cost fertilizer; press mud *i.e.* waste of sugar industry. The ambition for the conductance of this work was to investigate mineral position of forage (*Avena sativa* L.) and soil. As soil and forage are key starting place of minerals for plants and animals, correspondingly so for the appropriate mineral-diet relative it is obligatory to examine the mineral level in forages and soil (Ahmad *et al*., 2013). Keeping in view the significance of category and nature of OM on phytoavailability of metals, unusual amendments specifically, (PM), pressmud (PrM) are used. The current study was premeditated to explore and compare the consequence of press mud (PrM) on immobilization of nickel (Ni), and, copper (Cu) and their concentrations in soil and forage plant (*Avena sativa* L.). The rationale of this study was to explore the sugar mill press mud waste for bioavailability of some heavy metals like Ni and Cu. Absorption and accumulation of various metal elements by forages and fodders is of significance owing to the thump of anthropogenic emissions on soils and its results for human being absorption (Bradley, 2008). According to Sauve *et al.* (2000), partitioning Cd, Cu, Ni, Pb and Zn linking solid and solution phases is reliant on pH of soil solution, and soil entirety metal and natural substance contents. Therefore, the objective of this research was evaluating the Cu and Ni position of soil and forage that were fertilized with dissimilar doses of press mud (*i.e.* waste of sugar industry) as a low-priced compost.

MATERIALS AND METHODS

Study area

This work was conducted from December to April 2010 in University of Sargodha, Sargodha located in northeast of Pakistan, (32°8′0″ N, 73°7′0″ E). The mean precipitation is 180 to 200 mm and temperature varies from 7 to 23^{o}C during winter and 25 to 49^{o}C during summer. Total area of Sargodha is 5854 square kilometer.

Oat (*Avena sativa* L.) was planted in the first week of December as the seeds were grown in pots in polyethylene bags (10 plants in each pot) containing clay and loamy soil under 25/20^{o}C day/night temperature, 55-60% air humidity. Press mud was added as a treatment. Press mud was applied as split doses in half pots, and as full in rest of the pots. Twenty pots were assigned to split doses, twenty four full dose and five control pots were made for comparison i.e. eight treatments were applied in addition to the control (five replicates for each treatment). Press mud in full dose treatments was applied before sowing and in other remaining treatments (half-dose), the half dose of press mud was applied before sowing while the other half was applied before heading. Doses of applied press mud for either full or half-dose treatments were 600, 900, 1200 and 1500 kg ha^{-1}. Leaves of the plants were harvested at after 45 days of press mud application and it was termed as early leaves. Second harvest was performed after the production of grains. The complete randomized design (CRD) was used in this study. Different treatments of filter cake applied to soil (kg/h) before and after sowing the forage crop were given as under: 0 (Control), 600, 900, 1200 and 1500 and same doses of press mud after sowing were applied, respectively.

Polythene pots were used for sowing the seeds of plant and each plastic pot was lined with polyethylene bag. Seven (7) kg soil was taken in each plastic pot that was lined with polyethylene bag. The material was blended or mixed prior to use to ensure uniformity. The source of the press mud was sugar mill in the sub urban area of Sargodha, Pakistan. Plants were harvested at different intervals of time (1st harvest was taken 45 days after the emergence of seedlings and 2nd harvest was taken after the plant has produced the grains). Five replicates of plants from each dose were taken. Plants were irrigated with sub-soil water to keep optimum moisture level in soil.

Sample collection

Samples of soil and forages were taken randomly from pots that were given different doses with two different methods already explained. The soil samples were collected up to bottom of experimental pots and soil was blended with press mud before filling the pots. The collected samples of plants were cleaned with distilled water and diluted HCl to remove dust particles and other impurities. These samples were air dried, stored in labeled sealed paper bags and placed in an oven for 3 days at a temperature of 70°C.

Wet digestion and analyses

The incubated soil and forage sample were digested by the wet digestion method. The concentration of Cu and Ni in plant material well as in the pressmud was measured after digestion with H_2SO_4 and H_2O_2 in a Kjeldahl apparatus followed by atomic absorption spectrophotometry (Guudjak *et al*., 2004).

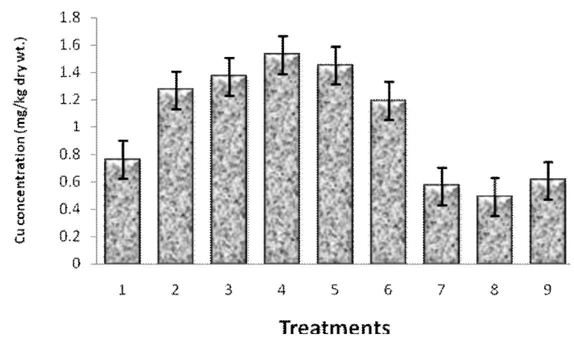
Statistical analysis

Data are means of five replications for Cu and Ni determination. One way analysis of variance (ANOVA) was used for the determination of significant difference between treatments using the software SPSS v 18, and statistical significance was tested at 0.05, 0.01 and 0.001 levels (Steel and Torrie, 1986).

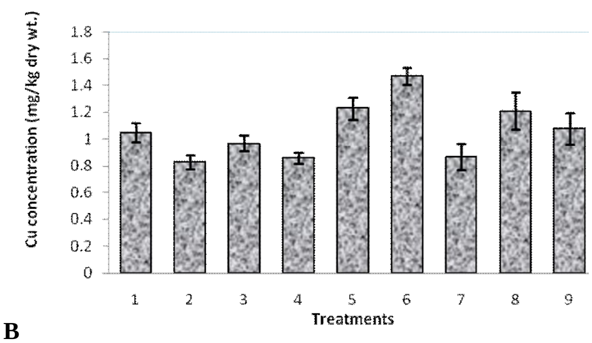
RESULTS AND DISCUSSION

Copper in soil and forage plants

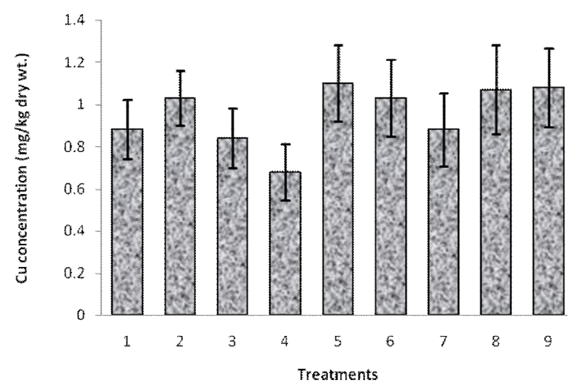
Analysis of variance of data for Cu concentration in soil showed non-significant effect (*P>0.05*) by the treatments. The much dissimilarity was found for 7th and 8th treatment. The range of Cu content in soil varied from 0.49 to 1.53 mg/kg. Lowest concentration was found in samples of 8th treatment. The highest concentration of copper was found in the 4th treatment (Fig. 1A). These results are consistent with earlier investigations by Gune *et al*. (2004). However slight differences were found by Shallari *et al*. (1998) and Zheng *et al*. (2004).



A



B



C

Fig. 1. Fluctuation in levels of copper in soil (A), early leaves (B) and late leaves (C) at different doses of treatment

The variance applied on the data of Cu concentration in forage showed non-significant effect (*P>0.05*) on late leaves and a highly significant effect (*P<0.001*) on early leaves.

Highest value of Cu concentration in forage was noted for early leaves of the 6th treatment (Fig.1B), while for the late leaves highest value was determined for the 9th interval (Fig.1C). Cu concentration ranged from 0.83 to 1.47 mg/kg and 0.88 to 1.08 mg/kg for early and late leaves, respectively. It was noted that the Cu concentration was less compared to that determined by Baker and Senef (1995) and Cui *et al.* (2007)

It is obvious that this little concentration is indicative of amount and accessibility of this element in soil. Normal content of Cu in plants ranged from 2 to 20 ppm. No part of plant had copper contents to the toxicity level. So animals did not have prospective hazard of utilizing this forage for their nutrition (Rehman *et al*., 2013). In addition, copper contents being lower than the decisive range necessitates addition of copper compost. Copper deficiency results in augmentation of iron in the liver, whereas an excess of copper consequences in diminishing of iron content of liver. Copper present in blood plasma as a copper-carrying plasma protein called erythrocuprin. provides a linkage amid copper and iron metabolism and mediates the discharge of iron from ferritin and haemosiderin (Hays and Swenson, 1985). The nutritional prerequisite of copper is exaggerated by the intensity of some other minerals in the diet, and is augmented in ruminants by disproportionate molybdenum. Management of copper poisoning is based on the justification that overload molybdenum may cause copper deficiency and molybdenum in concurrence with the sulfate ion has been used in treating copper poisoning in ruminants (Pierson and Aenes, 1958). The Cu requisite varies among animal species to some degree but is influenced to a great amount by its connection with and the ingestion of other mineral elements such as iron, molybdenum and sulfate.

Nickel in soil and forage plants

The Ni concentration in press mud was only 0.08 mg/kg. The value of Ni contents in soil after press mud treatment ranges from 0.55 to 1.76. Inconsistent variation patterns were found during treatment. There is not much difference between 6th and 7th treatments. The highest concentration of Nickel was found in the 5th treatment and lowest in 8th (Fig.2A). The critical level for Ni in soil is around 2.0-50 ppm (Gune *et al.*, 2004). Kabata-Pendias and Pendias (1984) reported that Ni concentration in soil may be as high as 100 mg/kg. In the present studies the Ni was marginally deficient, quite below the toxic level. The transfer of metals from soil to plants also depends on the physico-chemical characteristics of soils (Ibrahim *et al*., 2012).

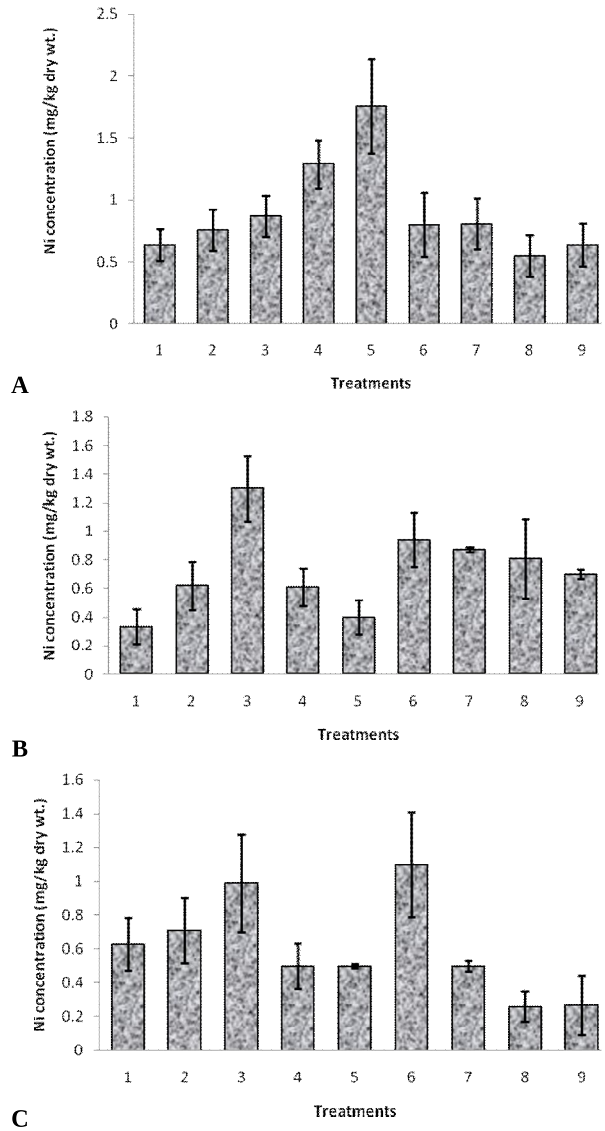


Fig. 2. Fluctuation in levels of Ni soil (A), early leaves (B) in late leaves (C) at different doses of treatment.

Analysis of variance of data on Ni concentration in forage showed that there is highly significant effect of press mud treatments (*P<0.001*) on (early and late) leaves. The highest Ni contents were found in the early leaves of 3rd treatment (Fig. 2B), while that for the late leaves of the 6th interval (Fig.2C). Ni ranged in early leaves from 0.33 to 0.94 mg/kg and 0.27 to 1.1 mg/kg in late leaves. Fundamentally underneath all ordinary field circumstances, it is improbable that application of nickel fertilizer will be essential. Essentiality of Ni is at the present well recognized for higher plants, though its elevated concentration might be poisonous to the plants (Farago and Cole, 1988) and could alter diverse physiological/biochemical processes (Morgutti *et al*., 1984; Jones and Hutchinson, 1988; Pandolfini *et al*., 1992; Seregin and Kozhevnikova, 2006). Nickel toxicity decreases membrane permeability due to higher extracellular peroxidase activity (Pandolfini *et al*., 1992). Nickel causes skin allergic reaction, aversion in occupationally exposed persons and is haematotoxic, immunotoxic, reproductive poisonous and carcinogenic mediator (Das *et al*., 2008).

Nickel polluted soils might be used securely for agricultural rationale by adopting unlike supervision options. Management approach, which takes care of diverse environmental hazard and human health, might be the paramount alternative (ATSDR, 2005; Demir *et al*., 2005). Application of organic amendments for metal immobilization is significant due to advantageous special effects on physico-chemical properties of soil (Karaca, 2004). Different soil and plant factors like nutrient condition of soils and plant species, gearshift the phytoavailability of metals in the soils and plants (Seregin and Kozhevnikova, 2006). Organic matter (OM) is the mainly imperative owing to its consequence on performance of dissimilar metals in the soil which controls accessibility of metals. Exceptions to this idea occur when urea is the chief cause of nitrogen supply, in species in which ureides play an significant physiological role (Martin and Ruby, 2004), when too much application of Zn, Cu, Mn, Fe, Ca, or Mg has been made over many years (Martin and Ruby, 2004), and possibly also in nitrogen-fixing crops grown on mineral-poor or highly nickel-fixing (high pH, high lime) soils. In experiments utilizing extremely purified nutrient solutions or tissue-culture media, supplemental nickel possibly will also be advantageous. Nickel is at present being applied to many fields in sewage sludge (Wood *et al*., 2004; Khan and Scullion, 2002). In wide-ranging, this practice does not signify a hazard to human health, as its accessibility to crop plants is characteristically low. The total extractable nickel in these amended soils can also be controlled by assortment of plant species and supervision of soil pH, moisture, and organic matter (Kukier and Chaney, 2001).

In recent years, a great deal of attention is being paid on nickel-accumulating plants that can endure nickel-toxic soils and amass considerable quantity of nickel, up to 5% on a dry weight basis (Boyd *et al*., 2002). Three nickel hyper accumulators showed significantly increased shoot biomass with the accretion of 500 mg Ni kg^{-1} to a nutrient-rich growth medium, signifying that the nickel hyperaccumulators have an elevated prerequisite for nickel compared other plants (Kupper *et al*., 2001). Substantial consideration is also being focused on utilizing hyper accumulating species for phytoremediation and phytomining, where they can be grown in a nickel-contaminated soil and then harvested and exported from the field. To date, however, this approach has not been flourishing owing to the small size and slow growth rate of hyper accumulating species. With a better understanding of the genetic basis of metal hyper accumulation, it may be possible to transfer this trait into a rapid growing agronomic species and therefore increase an effective phyoremediation strategy.

CONCLUSIONS

The present study has revealed that supplementing the soil with different doses of press mud did not modify much the Cu concentration in soil on early or late-harvested leaves of cultivated oat. In addition, the technique of application of press mud, *i.e.* only once before sowing as compared to two times; half before sowing and half before heading influenced the Cu and Ni concentration in soil and early-harvested and late- harvested leaves of oat. The Cu concentration in early-harvested leaves are lower than the toxic limit reported by the researchers, while the Ni concentration in the late leaves was elevated. It is assumed that feeding these forages to livestock would be safe, but the same is not factual for late leaves.

This study also suggests that trace elements were not readily accessible to forage crop from press mud, but the chelating agents in sediments can render the metals bioavailable. Therefore, it is recommended that during composting of pressmud, some chelating agent should be added for leaching of metals.

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