

# **RESEARCH ARTICLE**

#### EFFECT OF SOIL AMENDMENTS ON NI, CD AND PB DYNAMIC UNDER PADDY FIELD IRRIGATED WITH LOW WATER QUALITY.

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#### Abstract

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#### Key words:-

Oryza sativa, heavy metal, rice straw, rice husk, compost, biochar

The experiment was conducted to see the hypothesis of reducing the impact of irrigation water contaminated with heavy metals using some soil amendments and its effect on rice yield. A site was selected near kafr El sheikh governorate, Egypt. Due to water shortage in this area farmers are forced to use low water quality for irrigating his paddy field. This experiment investigated the effect of six soil amendments { rice straw (RS), rice straw compost (RSC), rice husk (RH), rice husk compost (RHC), rice husk biochar (RHB) and wood-dust biochar ( WDB)} in addition to control on the growth of rice (cv. Giza 178) and heavy metals dynamic in paddy soil that was irrigated with low water quality. The best results were from the application of RHB that increased grain yield, and decreased Ni, Cd and Pb concentrations in straw and grain. The other soil amendments under study also increased the grain yield, and effectively decreased the Ni, Cd and Pb concentrations in straw and grain. Concentrations of Ni, Cd and Pb in grain and straw were dependent on the available of them in soil. The mean value of CEC of soil under RHB was highest. Among the soil amendments the heavy metals concentration in straw and grain were ranged as follow; RHB < WDB < RH< RHC < RSC < RS < control. Finally RHB or WDB can be considered as a by-product material for application under paddy field irrigated with low water quality.

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#### Introduction:-

Conventional water resources in Egypt are limited to the Nile River; groundwater in the deserts and Sinai, and precipitation. Each resource has its limitations on use. These limitations relate to quantity, quality, space, time, and/or use cost. The Nile is the main and almost exclusive source of fresh water in Egypt. Egypt relies on the available water stored in Lake Nasser to meet needs within its annual share of water, which is fixed at 55.5 Billion Cubic Meters (BCM) annually by agreement with Sudan in 1959 that is not sufficient to meet the water requirements of the agricultural land in Egypt. In Egypt, the total agriculture land amounts to 8 million feddan (1 feddan = 1.04 acre), which represents 3.8% of the whole area of the country. The most important crops are wheat and berseem in winter, cotton, rice and maize in summer. Water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote

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further development. The potential for irrigation to raise both agricultural productivity and the living standards of the rural poor has long been recognized. This potential is even more pronounced in the north part of Egypt, such as Kafe El Shiekh, El Behera, Dakhlia and Domiata regions where there is fresh water shortage for agricultural production. Also, more than 70 percent of the total rice cultivation area is found in these regions (Rice National Campaign, 2012). Rice is an important cash crop of these regions. Its water requirement is more than any other crop. However, due to the shortage of canal water, the farmers use underground as well as surface water Therefore, the urban soils of the country are often irrigated with treated wastewater for growing crops to compensate the Nile water shortage. As a result of the use of wastewater for irrigation, trace metals have accumulated in agricultural soils. The connection between soil and water contamination and metal uptake by plants is determined by many chemical and physical soil factors as well as the physiological properties of the crops. Soils contaminated with trace metals may pose both direct and indirect threats to plants: Direct, through negative effects of metals on crop growth and yield, and indirect, by entering the human food chain with a potentially negative impact on human health. Even a reduction of crop yield by a few percent could lead to a significant long-term loss in production and income. Some food importers are now specifying acceptable maximum contents of metals in food, which might limit the possibility for the farmers to export their contaminated crops. Therefore the protection of soils from trace metal pollution is essential for maintaining a good soil and food quality. Once soil is contaminated, it is difficult and expensive to decontaminate it (Bjuhr, 2007). Heavy metals are terribly released into the environment because of the rapid industrial growth in various sectors and have created a major global threat. The industrial wastewaters originated from metal plating, mining activities, smelting, battery manufacture, tanneries, petroleum refining, paint manufacture, pesticides, dye manufacture, printing and photographic industries etc. are often detected with the heavy metals like cadmium, zinc, copper, nickel, lead, mercury and chromium (Rangab hashiyam et al., 2013; Kadirvelu et al., 2001; Williams et al., 1998). The management of heavy metals is of special concern due to its recalcitrance and persistence nature of existence in the environment (Fenglian and Wang, 2011). Wastewater use in irrigated crop production is a highly complex issue, with opportunities and risks and agronomic, economic, ethical and human and ecosystem health dimensions. Wastewater influenced production systems are characterized by an enormous variability in bio-physical and socio-economic conditions and the true complexity is generally poorly understood except for a few reported case studies (Scott et al. 2003). Recognizing as a preamble that the agronomic dimension of soil, water and crop management is crucial for understanding and optimizing wastewater irrigation. this study focuses on agronomic aspects of wastewater influenced irrigated rice production systems in Egypt where wastewater influenced irrigation is common in some cultivated rice areas. Although some of them, such as Fe, Zn, Mn and Cu etc., are essential at the low level, other metals, like Cd, Cr, Pb and Ni, are toxic and may pose a great threat to plants, animals and humans through the food chain (Costa, 2000). High contents of heavy metals in soils would increase the potential uptake of these metals by plants. Therefore, a detailed risk assessment of heavy metal accumulation in agricultural lands is required for application of inorganic fertilizers, organic wastes and byproduct materials to soils in order to ensure the safe crop production (Papafilippaki et al., 2007). Heavy metals in soils may be present in several forms with different levels of solubility as follows: (i) dissolved (in soil solution), (ii) exchangeable (in organic and inorganic components), (iii) structural components of the lattices in soils and (iv) insolubly precipitated with other soil components (Zalidis et al., 1999; Aydinalp and Marinova, 2003). Usually, only the first two forms are able to be absorbed and utilized by plants. Therefore, plant uptake of a metal is mainly dependent on the metal mobility and availability in soils. The application of material substances such as soil amendments (EPA, 2011), Biochar (Zhang, 2009), calcium carbonate, and manganese oxide (Chen et al., 2009) has successfully mitigated soil heavy metal contamination, and significantly reduced the contents of available heavy metals in soils, as well as the uptake by plants, mostly due to the adsorption phenomena by some soil amendment. Organic materials such as green manure, animal excrement, Biochar and peat can also actively remedy heavy metal contaminated soil by transforming heavy metals from soluble and exchangeable fractions to fraction associated with organic matter (OM), carbonates fraction, and residual fraction, which are unavailable to plants (Shuman, 1999; Walker et al., 2003). Soil amendments can be used to address two primary categories of problems at contaminated sites: (1) contaminant bioavailability and phytoavailability; and (2) poor soil health and ecosystem function (EPA, 2011). The objective of this study was to investigate the effects of some by-product materials such as Biochar, rice husk and rice straw on the bioavailability and the uptake of Ni, Cd and Pb by rice in a paddy soil that was irrigated with low water quality.

## Materials and methods:-

### Soil amendments preparation

Biochars used for this experiment were produced by pyrolysis the rice husk and wood dust at 420 °C with the absence of oxygen in International Trade and Marketing Company, Kaha, Al kaliobia governorate. The production

information of the biochar was given in detail by Pan et al. (2011). In brief, rice husk and wood dust were collected and air-dried. Pyrolysis process was performed in a vertical kiln at 400–450 °C, converting 35% of the biomass to biochar with the absence of oxygen. Compost was prepared at the Central Laboratory for Agriculture Climate through mixing both rice straw and husk by caw manure for 120 days up to maturity. Rice straw was chopped up to 2-3 cm before application either for composting or for direct soil application. The basic properties of all soil amendments in this experiment were given in Table 1.

Soil amendments	Unit	RH	RHC	RS	RSC	RHB	WDB	
рН		6.41	7.6	6.87	7.8	8.72	9.04	
N	%	0.32	1.2	0.64	1.5	0.1	0.2	
С	%	43.4	20	36.56	25	28.72	29.87	
CEC	$( \text{ cmol } \text{kg}^{-1} )$		39.74	-	38.12	44.57	45.12	
Ca	//	1.2	22.5	-	21.5	34.2	35.01	
K	//	1.6	24.00	-	22.1	32.6	31.54	
Mg	//	1.5	7.50	-	8.67	14.2	15.50	
Rice husk(RH); Rice husk compost (RHC); Rice straw(RS); Rice straw compost(RSC); Rice husk biochar(RHB);								
Wood-dust biochar(WDB)								

Table 1: The characteristics of the soil amendments

### **Experimental setup:-**

The experiment was carried out during the year 2015 and 2016 at the farm of at farm of Sakha Agricultural Research Station, Kafr el sheikh city (310 N, 31.10 E). The study area is located at the north pat of Egypt. Due to fresh water shortage in this region, most of the agricultural lands are using drainage water for irrigation. six soil amendments { rice straw (RS), rice straw compost (RSC), rice husk (RH), rice husk compost (RHC), rice husk biochar (RHB) and wood-dust biochar (WDB)} in addition to control. The amount of soil amendment applied (Chun et al., 2004; Yuan et al., 2011) was calculated based on the plot area (as shown in table 2), and the amendments were incorporated into a 20 cm depth of soil. All plots were irrigated from Drainage Canal Eight located at Sakha Research station, Kafr El Shiekh, the canal water usually derived from both industrial and Sewage water as characterized in table 3.

Rice cultivar Giza 178 (*Oryza sativa*) was cultivated under the six treatments as mentioned above. The treatments were arranged in to strip plot design with four replications. Each plot about  $50m^2$  area. A basal dose of phosphorus was applied at the rate of 36 Kg P h<sup>-1</sup> and zinc was added at the rate of 24 Kg Zn ha<sup>-1</sup> as ZnSO<sub>4</sub> in dry soil. Nitrogen fertilizer was split-applied as a Urea at the rate of 150 Kg ha<sup>-1</sup>; 2/3 of N dose was incorporated before flooding and 1/3 was applied at the panicle initiation stage. The rice seeds were sown in the last week of April for the nursery. After 25 days, 4-6 plants per hill were transplanted at a spacing of 20x20 cm. Crop was harvested, in the last week of September, from each treatment within an area of 5 m<sup>2</sup> to determine the yield (ton ha<sup>-1</sup>).

### Sampling and chemical analysis:-

Soil texture was determined by the pipette method (Soil Survey Laboratory Staff, 1992). Soil organic matter was measured by the modified Walkley and Black method as described by Allison. Total N was measured using Kjeldehl method (Bremner and Mulvaney (1982). Water-soluble phosphorus was determined colorimetrically by a spectrophotometer and the contents of water-soluble Ca, Mg, Na, and K were determined using an atomic absorption spectrophotometer (AAS). The pH was measured in a saturation paste, and the electrical conductivity of the saturation extract (ECe) was measured using an electrical conductivity meter (Page et al., 1982). The CEC was extracted with 1M NH<sub>4</sub>OAC (buffered at pH 7.0), and exchangeable base concentrations were measured using AAS (Shimatzu). Irrigation water samples were collected through the growing season to determine the chemical analysis as shown in Table 4. Samples of shoot and grain of rice plant were selected for determining heavy metals concentration. At harvest time, Five hills of mature rice

No.	Treatments	Symbol	Amount (t/ha)			
1	control	Со				
2	Rice husk	RH	10			
3	Rice husk compost	RHC	8			
4	Rice straw	RS	10			
5	Rice straw compost	RSC	8			
6	Rice husk biochar	RHB	8			
7	Wood-dust biochar	WDB	8			
Application rate according to Masulili and Utomo. 2010						

Table 2: Experimental design for the soil amendments

Table 3: Chemica	l analysis	of soil	and the	irrigation	water
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Table 3: Chemical analysis of soil and the irrigation water									
Items	unit	Soil	Irrigation water						
			2015	2016					
Sand	%	11.52							
Silt	%	30.93							
Clay	%	58.50							
Texture class	-	clayey							
EC	dSm <sup>-1</sup>	1.8	2.26 8.05	2.51					
рН		7.68		7.10					
Total N	mg kg <sup>-1</sup>	4516							
Soluble P (Olsen)*	mg kg <sup>-1</sup>	18.6							
Water-soluble K	meq kg <sup>-</sup> 1	1.39	Total 0.28						
heavy metals		Available	0.15 0.34	Total 0.27					
Nickel (Ni)	mg kg <sup>-1</sup>	0.13		0.17 0.36					
Cadmium (Cd)	mg kg <sup>-1</sup>	0.03							
Lead (Pb)	mg kg <sup>-1</sup>	0.18							
*Olsen et al., 1954									

plants from each plot were also sampled. The sampled plants were washed with tap water and deionized water in the order, then separated into straw and grains, oven-dried in an oven at 80 C<sup>o</sup> to constant weight and the grains were milled into powder for measurement of heavy metal content. Thereafter, the samples were ground into powder form to pass a 1mm-sieve and digested with a mixture of sulfuric acid ( $H_2SO_4$ ) and hydrogen peroxide ( $H_2O_2$ ) at 240 to 260 C<sup>o</sup> for 5 hours. The concentrations of heavy metals (Ni, Cd and Pb) were determined using the AAS. Soil samples also were taken from paddy soil (0-30 cm) for determining available Nickel (Ni), Cadmium (Cd) and Lead (Pb) according to methods given in Handbook by Soltanpour (1985) and Page et al. (1982). The same procedure without samples was used as blank. Three replications were conducted for each sample. Plant metals uptakes were calculated based on biomass and metals contents in plants.

For analysis of available heavy metals in soil, air-dried soils were extracted by a die thylenetriaminepenta acetic acid (DTPA) extract using an AAS. A hundred ml of 0.05m DDTPA per 10 g of soil was shaken for 3 hours at room temperature, and then the solution was filtered (14) (Page *et al.*, 1982). Metal contents in the supernatant liquid were measured with a flame atomic absorption spectrometry (FAAS). The same procedure without samples (blank) was used as control. The bioaccumulation factors were calculated as the ratios of metals concentrations in brown grain to the concentration in 0-20 cm paddy soils (Rezvani and Zaefarian, 2011).

The plant's ability to accumulate metals from soils can be estimated by the following equation (Modified from Manahan 1992):

$$FB = \frac{CP}{CS}$$

Where: FB = bioaccumulation factor; CP = metal's concentration in plant organs (grain); CS = metal content in soil

### Statistical analysis

Data were statistically analyzed by ANOVA test and L.S.D using a statistical analysis GenStat program and the soil amendments were compared for heavy metals concentration in straw, grain and soil using the least significant difference (LSD) test at 5% level of significance.

Table 4: Soil pH, Eh, EC under different soil amendments

### **Results and discussion:-**

### Effects of amendments on soil pH, CEC, Eh

The results of soil analysis of some soil chemical properties after harvest are shown in Table 4. The soil properties increased significantly with the application of soil amendments. There is no significant different between RHB and WDB for soil pH, Eh, and CEC. The increase in soil CEC showed that fairly large amounts of exchangeable cations

Soil amendments	pH		CEC		Eh	
				meq 100g <sup>-1</sup>		
	2015	2016	2015	2016	2015	2016
СО	7.22	7.32	17.25	18.5	-24	-22
RH	7.52	7.55	24.89	25.45	-25	-26
RHC	7.65	7.60	25.04	28.02	-35	-38
RS	7.10	7.15	21.58	22.87	-44	-48
RSC	7.51	7.52	22.75	23.74	-38	-40
RHB	7.95	8.02	35.40	36.54	-23	-24
WDB	7.92	7.89	36.54	36.45	-23	-23
LSD 0.05	0.10	0.20	9.64	10.23	5.21	5.87

Rice husk(RH); Rice husk compost (RHC); Rice straw(RS); Rice straw compost(RSC); Rice husk biochar(RHB); Wood-dust biochar(WDB)

were introduced by soil amendments application. Also the increase of soil pH under pots amended with RHB or WDB could be due to the higher pH in Biochar itself in addition to slow discharge of  $NH_4$  which was stored in porous of Biochar from fertilizer application during the season. The Lowest soil Eh under pot amendment with RSC, RS may be attributed to the low oxidation condition compared to the other soil amendment under study. A chain of reactions is initiated upon soil flooding leading to reduced (low) soil redox potential (Eh, mV) conditions. These reactions include physical, chemical and biological processes that have significant implications for wetland plants (Gambrell and Patrick, 1978; Gambrell et al., 1991). Physical processes include restriction of atmospheric gas diffusion in the soil leading to the depletion of soil oxygen and the accumulation of carbon dioxide due to accumulation of organic matter (Jackson and Miller, 2000, Greenway, 2006). Shortly after flooding, with organic matter application the limited supply of oxygen in soil pore spaces is depleted rapidly by roots, microorganisms, and soil reductants (Ponnamperuma, 1972). This process leads to oxygen depletion and reduction in soil oxidation reduction potential (Eh) followed by a chain of soil chemical changes. The processes that follow include denitrification, reduction of iron, manganese and sulfate, and changing soil pH and Eh (Gambrell et al., 1991).

For the soil amendments of RSC, RHC and RS, the soil pH was increased in both seasons. This may be attributed to the release of  $NH_4$  in the process of decomposition of organic matter during the growing season; Therefore, biochar as a soil amendment can improve soil quality by increasing soil Eh, pH, and CEC, under flooding condition. The soil pH and CEC values of different soil amendments followed the order: RHB>WDB>RHC>RH>RSC>RS. Regarding to soil Eh the order; RHB>WDB>RHC>RSC>RS. The concentrations of available Cd, Ni and Pb in the soil decreased consistently with the application of soil amendments (Table 4), suggesting that these amendments reduced the bioavailability of the three heavy metals under study. Compared with the control, the application of RHB, WDB, RHC and RH significantly lowered the concentrations of available Cd, Ni and Pb in both seasons. However, only slight decreases in the concentrations of available Cd, Ni and Pb in both seasons of different amendments followed the common order: RHB>WDB>RHC>RH>RSC>RS>CO which reversed the order of the soil pH except for RS treatment. It can also be concluded that with the application of soil amendment application. Soil available Cd, Ni and Pb in both seasons were significantly negative that with the application of soil amendment application. Soil available Cd, Ni and Pb in both seasons of different amendments followed the common order: RHB>WDB>RHC>RH>RSC>RS>CO which reversed the order of the soil pH except for RS treatment. It can also be concluded that with the application of soil amendment application. Soil available Cd, Ni and Pb in both seasons were significantly negative the soil pH except for RS treatment. It can also be concluded that with the application of soil amendment application. Soil available Cd, Ni and Pb in both seasons were significantly affected by the soil pH (Fig.1), and the correlation between them can be described by the following regression equations (Eq.(1))

$$y = -17.404x + 10.888 (R^2 = 0.9296 P < 0.01)$$

#### For Ni

$$y = -1.0915x + 11.34 (R^2 = 0.3314 P < 0.01$$
(1)

#### For Pb

 $y = -2.5236x + 13.809 R^2 = 0.9758 P < 0.01$ 

Where, *Y* represents the concentration of available Cd ,Ni or Pb in soil (mg kg<sup>-1</sup>), *X* represents the soil pH. Several studies have proved that the soil pH is an important



Figure 1:- Correlation between soil pH and the heavy metal under study ( the data is average of two years).

factor controlling the mobility of heavy metals in soils (Wallace *et al.*, 1974; Jackson and Miller, 2000). Besides the soil pH, there are other factors such as CEC and Eh that may also affect the bioavailability of heavy metals particularly under flooding soil condition. The properties of the soil amendments as well as the undergoing cations exchange were related to the decrease in the available Cd ,Ni or Pb in the soil. For example, Biochar can release OH- and consequently able to hydrolyze heavy metals cations ( $Cd^{2+}$ , Ni<sup>+</sup> and Pb<sup>2+</sup>) to Cd-OH<sup>+</sup>, Ni-OH or Pb-OH which can be adsorbed tightly by soil or Biochar itself, and can thus decrease the availability of these heavy metals (Prasad, 1995). On the other hand, organic amendments such as RSC and RHC enhance the adsorption of heavy metal by soil through forming stable complexes with heavy metal ions, and then decrease their mobility and extractability (Piccolo, 1996; Naidu *et al.*, 1997; Chen, 2000). In this study, the soil pH and the concentrations of available Cd, Ni or Pb in the soil in the Biochar treatments were all lower than the other soil amendments under study. This may be attributed to the enhanced heavy metal adsorption and sorption owing to the large specific surface areas, rich with fiber carboxyl acids groups, and strong ion exchange capacity in Biochar treatment (Wang et al., 2007).

In general, the mobility and availability of heavy metals are controlled by adsorption and desorption characteristics of soils (Krishnamurti *et al.*, 1999). The adsorption and desorption of heavy metals have been demonstrated to be associated with soil properties, including pH, organic matter content, CEC, oxidation reduction status, the contents of clay minerals, calcium carbonate, Fe and Mn oxides (Kashem and Singh, 2001; Antoniadis et al., 2008; Usman et al., 2008). Although the Eh values under biochar treatments are not the main significant factor affecting the heavy metal availability compared with other soil amendments under study, the availability of heavy under study decreased under biochar application,. A high proportion of carboxyl acids as well as other acidic oxygen groups may also provide biochar many of the desirable properties of humic acid which is an important component of soil organic matter. The relatively high concentration of acidic groups can allow the formation of chelates with metal ions and help to bind positively charged ions to the surface of the carbon. When the surface density of carboxylic acid groups is very high, chelates with metal ions can almost completely immobilize potentially toxic metal compounds. The results obtained by Valdes (2002) indicate that total acidic groups on carbonaceous material can reach at least 2 meq g<sup>-1</sup> with half the acidic groups being carboxyl groups. The acidic nature of oxidized biochars means that they may be well suited for retention of basic ions such as ammonium or other cation compounds (Kastner, 2009).

## Effects of soil amendments on Ni, Pb and Cd dynamic:-

Metal uptakes in total and the aboveground plant biomass were calculated and listed in Figure 2. As a result of increased metals concentrations in the aboveground, metals uptakes in rice plant were mostly higher in RS treatment compared with other soil amendments under study. For the uptakes in aboveground organ of rice, uptakes of Cd, Ni and Pb were almost the same under both RHB and WDB in both seasons. From Table 5 also, it can be estimated that the reduction of heavy metal concentrations in straw compared to the control are as follows ; Cd ranged from 16.70 to 33.00 % and 12.40 to 35.30 % and Ni ranged from 6.21 to 44.20% and 8.13 to 31.5% and Pb ranged from 7.00 to 16.40% and 12.6 to 14.30 % in both years respectively. On the other hand, there is no significant different between the concentration compared with other soil amendments under study, implying that the application of RHB or WDB may result in higher effect on reducing Ni, Cu and Cd uptake by rice plant. The decrease of Ni, Cd and Pb concentrations in grain and straw of rice was related to the change of Ni, Cd and Pb fractions in soil. Castaldi et al. (2005) found significant decrease of Cd concentrations in root and shoot of white lupine after the addition of compost and

Soil amendments	Cd		Ni		Pb			
	mg Kg <sup>-1</sup>		mg Kg <sup>-1</sup>		mg Kg <sup>-1</sup>			
	2015	2016	2015	2016	2015	2016		
СО	0.27	0.23	4.11	3.92	3.5	2.95		
RH	0.19	0.19	3.55	3.31	2.64	2.36		
RHC	0.17	0.18	3.42	3.24	2.40	2.22		
RS	0.23	0.21	3.78	3.53	2.88	2.56		
RSC	0.20	0.19	3.69	3.40	2.68	2.40		
RHB	0.12	0.16	3.15	2.82	2.31	2.20		
WDB	0.12	0.17	3.12	3.00	2.33	2.25		
LSD 0.05	0.05	0.02	0.30	0.22	0.21	0.20		
Rice husk(RH); Rice husk compost (RHC); Rice straw(RS); Rice straw compost(RSC); Rice husk biochar(RHB);								

Table 6: The DTPA extractable Cd, Ni and Pb in soil as affected by different soil amendments

Wood-dust biochar(WDB)

 Table 5:- Concentration of Cd, Ni and Pb in rice straw under different soil amendments

lime; they also found that compost and lime decreased the Cd fraction extracted with H2O and Ca(NO3)2 and increased the residual fraction of Cd. Narwal and Singh (1998) also reported that pig manure and peat decreased the concentration of DTPA extractable Cd (available) in soil, but increased Cd in residual fraction. In the present study as shown in Table 6, the concentrations of available Ni, Cd and Pb under the soil amendments decreased by 14.45-55.50 % and 17.39-30.43% for Cd and 8.03-24.08% and 9.94-28.06% for Ni, and 17.71-34.00% and 13.22-25.42% for Pb in both years respectively. Furthermore, soil adsorption capacity also affected the uptake of heavy

Soil amendments	Cd		Ni		Pb	
	mg Kg <sup>-1</sup>		mg Kg <sup>-1</sup>		mg Kg <sup>-1</sup>	
	2015	2016	2015	2016	2015	2016
СО	15.97	13.97	63.06	61.32	131.54	122.80
RH	11.90	11.25	51.89	50.14	121.85	117.20
RHC	10.25	10.72	78.55	46.97	119.52	115.24
RS	13.30	12.30	59.21	55.96	122.04	119.96
RSC	12.06	12.06	44.84	48.51	120.74	119.00
RHB	9.85	9.04	41.25	42.20	110.21	105.30
WDB	10.02	9.06	41.55	43.05	111.45	105.41
LSD 0.05	2.05	1.62	3.66	3.59	10.55	9.02

Rice husk(**RH**); Rice husk compost (**RHC**); Rice straw(**RS**); Rice straw compost(**RSC**); Rice husk biochar(**RHB**); Wood-dust biochar(**WDB**)

metals by plants. For example, organic amendments can increase the absorption and immobilization of these metals in soil, and therefore decrease the uptake of these metals by rice (He and Singh, 1993).

Table 7 shows that the RHB and WDB treatments decreased the concentration of the heavy metals in grain in both years. However, the heavy metals concentrations in rice grain recorded the highest values under RHC, RSC, Rh and

RS. This may be because either the adsorption more of some available heavy metals on RHB and WDB than other the soil amendments or due to their function group or specific surface area. In addition, the decrease of Ni, Cd and Pb concentrations in grain and straw of rice in the treatments of amendments application may be partially attributed to the dilution effect caused by the significant increase of rice yield. The heavy metals concentration in rice grain under the soil amendments followed the same order: RHB < WDB < RH< RHC < RSC < RS < control. The concentrations of the heavy metals in rice grain were lower than those in straw regardless of the sources of amendments.

Bioaccumulation factors of metals under different soil amendments were listed in Table 8. It indicated that grain accumulated more metals under RSC, RHC and RS and accumulated fewer metals under RHB and WDB. Compared with control, there are high significant different between soil amendments for bioaccumulation in rice grain in both years, although there is no significant different found between RHB and WDB in both years.

Heavy metals in soils affect yield after their uptake and accumulation in tissues. Moreover, the accumulated heavy metals could severely harm human health through the food chain (Sorrell, 1999; Pezeshki, 2001). International Agency for Research on Cancer (IARC) has reported that Cd and Pb were believed to be carcinogens for humans (Van Wijck et al., 1992; Laskov, 2006). In the present study,

Table 8:- Bioaccumulation factors of Cd, Ni and Pb in rice grain as affected by different soil amendments.

Soil amendments	Cd		Ni	Ni		Pb			
	2015	2016	2015	2016	2015	2016			
СО	0.96	1.09	0.08	0.07	0.08	0.06			
RH	0.74	0.74	0.07	0.07	0.07	0.07			
RHC	0.88	0.72	0.07	0.06	0.08	0.07			
RS	0.70	0.71	0.07	0.07	0.07	0.07			
RSC	0.75	0.74	0.06	0.07	0.07	0.07			
RHB	1.00	0.75	0.05	0.06	0.06	0.06			
WDB	1.00	0.76	0.06	0.06	0.06	0.07			
LSD 0.05	0.13	0.18	0.01	0.01	0.01	0.01			
Rice husk(RH); Rice husk compost (RHC); Rice straw(RS); Rice straw compost(RSC); Rice husk biochar(RHB);									
Wood-dust biochar(WDB)									

LSD<sub>0.05</sub>=3.60

Fig. 2: Uptake of Cd, Ni and Pb in rice plant under different soil amendments

( the data is average of two years).

Rice husk(RH); Rice husk compost (RHC); Rice straw(RS); Rice straw compost(RSC); Rice husk biochar(RHB); Wood-dust biochar(WDB)



#### LSD<sub>0.05</sub>=0.30

Fig. 3: Grain yield as affected by soil amendments ( the data is average of two years).

grain yield of rice had no differences between all soil amendments under study except RS treatment (figure 3). the grain yield of rice under the soil amendments followed the order: RHB > WDB > RHC > RSC > RH > RS > control. these results mean that soil amendments were able to promote grain yield obviously except RS.

It is concluded that the application of amendments induced rice growth, and significantly increased the yield of rice grain. Soil pH was increased and the bioavailability of Ni, Pb and Cd was decreased significantly consistent with amendments application. The availability of Ni, Cd and Pb were significantly affected by the soil pH, and the soil adsorption capacity also affected the bioavailability of the heavy metals under study. The available Ni, Cd and Pb in soil were significantly correlated to the soil pH. Rice husk biochar demonstrated the best efficiency among all the

amendments in this study; it increased grain yield and decreased the concentrations of Ni, Pb and Cd in rice straw and grain. Application of these amendments also increased the grain yield, yet reduced the heavy metals concentrations in rice straw and grain below the tolerance limits of Ni, Pb and Cd in foods. However, the heavy metals concentrations in rice grain under soil amendments are not exceeded the limit. It is mentioning here the concentration of the studied heavy metals in straw or grain of rice is less the permissible limits as reported by El Sharkawi, et al., 2012. Based on these results, either RHB or WDB could be recommended to remediate the contaminated soil irrigated with low water quality.

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