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# UTILIZATION OF WASTEWATER TREATED WITH RICE HUSK BIOCHAR FOR IRRIGATION AND PRODUCTION OF RICE PLANT

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## ABSTRACT

*A greenhouse pot experiment was conducted during the rice growing season (mid- May to mid-October 2012) at Rice Research and Training Center (Sakha, Kafr- El Sheikh Governorate, Egypt) to evaluate the effect of wastewater irrigation on rice growth, development and productivity. Cadmium and lead contents of different rice plant organs including the grains were also detected. The results revealed the profitability of using wastewater for rice plant irrigation. The growth and yield parameters were increased with irrigation by untreated wastewater than by the treated wastewater. Cadmium and lead contents in the rice plant organs and used soil were higher by wastewater than by wastewater previously treated with rice husk biochar. These findings elucidate the efficiency of rice husk for wastewater purification especially from cadmium and lead. Wastewater irrigation for rice cultivation elevated cadmium and lead content in soil and plant.*

***Keywords:*** *wastewater, rice husk, rice production.*

## INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population; most of them live in developing countries. This crop occupies one-third of the world total area planted with cereals and provides 35–60% of the calories consumed by 2.7 billion people. Rice production must be increased by 65c/o to cope with the estimated population growth in rice–consuming countries by 2020 (IRRI, 1989).

Increasing rice crop production is a significant goal in Egypt's strategy for sustaining the important food crop self-sufficiency. Because of fresh water shortage we have to use another sources of water. Now days, measures for controlling heavy metal emissions into the environment are essential (Maximous *et al.,* 2010).

The use of contaminated water in the rice fields causes increasing lead and cadmium contents of the rice grains and the consumption of this rice causes accumulation of the heavy metals in the human body (Bakhtiarian *et al.,* 2001). The countries whose main food is rice, the contaminated rice causes a marked intake of cadmium. In Indonesia, 50 percent of their cadmium intake comes from the rice they consumed; this amount is 40 to 60 percent in Japan (Susuki, 1988a &b).

Adsorption is a friendly technique for the removal of heavy metal contaminants. This process-seems to be the most effective method for removal of heavy metal (Said, 2010). Conversion of solid wastes into effective low-cost adsorbents for wastewater treatments could decrease costs for removing heavy metals. In general, an adsorbent can be termed as a low cost adsorbent if it requires little processing, abundant in nature, or a by-product or waste material from industry (Nasim *et al.,* 2004). Therefore, there is an urgent need that all possible sources of agro-based inexpensive adsorbents like rice husk and rice husk derived biochar. In Egypt, rice husk and rice husk derived biochar rice husk and rice husk derived biochar should be explored and their feasibility for the removal of heavy metals should be studied in detail to alleviate or reduce the impacts of industrial water pollution on the aquatic environment. This work aims to highlight the utilization of wastewater treated with rice husk biochar for irrigation and production of rice plant.

## MATERIALS AND METHODS

The present study was carried out at Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt. Giza178 rice cultivar (*Oryza sativa* L.) was used for the present study. Large pots containing 23 kg of cultivated land soil and other small pots filled with 5 kg of soil were used. Rice plants were cultivated and treated with 2 types of irrigation water treatments as follows:

1- The first pots were irrigated with untreated wastewater (W).
2- The second pots were irrigated with wastewater treated by rice husk biochar resulted from pyrolysis of raw rice husk at 500°C (TW).

The pots were irrigated and fertilized according to the recommended regime of rice plant (Rice Research and Training Center, Sakha, Kfr El-Sheikh Governorate).

The growth parameters and cadmium and lead analysis were carried out in plant samples collected after 30 and 45 days of sowing from the small pots ,the third at harvesting time (after 135 days) from the large pots. The plant samples were dried, powdered and analyzed for determination of cadmium and lead concentration.

Soil samples were taken before cultivation, at 45 days and after harvesting of plants and then analyzed for investigation of cadmium and lead concentrations. The obtained data were statistically tested by ANOVA.

### A- Growth parameters

#### 1- Shoot and root length (cm)

Height of the main shoots (cm) of rice plants were measured from the base of stem up to the flag leaf tip, at the two growth stages. Root length (cm) of the plants was also measured.

#### 2- Shoot and root fresh and dry weights (g)

The shoot and root fresh and dry weights (g) of rice samples were recorded. The plants were dried to constant weight in an oven at 60-70_ to estimate their dry weight.

**3- Yield characters**

Heading date, panicle length, panicle number, grains number per panicle, grains number per plant, 1000 grains weight and single plant yield were determined at harvesting.

**B- Cadmium and lead contents**

Cadmium and lead contents of rice plants and soil of cultivation were extracted by wet digestion and investigated by atomic absorption technique, Perkin Elimer 3300.

**C- Statistical Analysis**

The obtained results were statistically analyzed in order to test the significance of variation, between the different treatments.

## RESULTS

**A. Growth Parameters of rice (*Oryza sativa L.*)**

**1-Shoot and root length**

The data presented in Figure (1) showed that, the shoot system of the studied rice cultivar was longer in untreated wastewater irrigated pots (W) than treated wastewater irrigated pots (TW) during the two growth stages. The increase percentage in the mean shoot length between (TW) and W plants was 4.52%. The root length exhibited the same trend. The mean root length at the end of the growing season showed increase 9.25% in root length between W pots and TW.

**2- Shoot and root fresh weights**

The data illustrated in Figure (2) showed that, the studied rice plants exhibited higher shoot fresh weight than root. The shoot and root fresh weights were higher in W pots than TW pots during the two different growth stages. The mean shoot and root fresh weights were increased at the end of the growing season in W pots plants by 10.65 and 9.70%, respectively.

**3-Shoot and root dry weights**

The mean shoot dry weight was mostly higher than the root dry weight (Fig. 3). The studied rice plants exhibited higher shoot and root dry weights in W irrigated pots than TW pots during the three different growth stages. The increase percentage in the mean shoot and root dry weights of rice plant of TW and W pots were 10.64% and 14.40%, respectively.

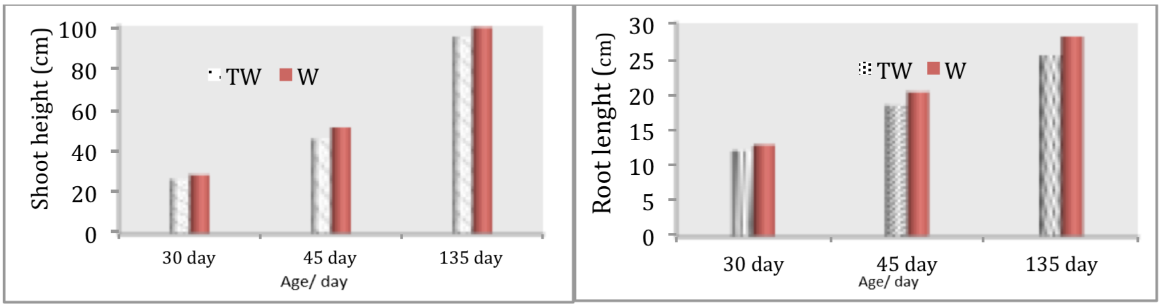


**Figure (1) :** The mean shoot and root lengths (cm) of rice plants irrigated with treated (TW) and untreated (W) wastewater.

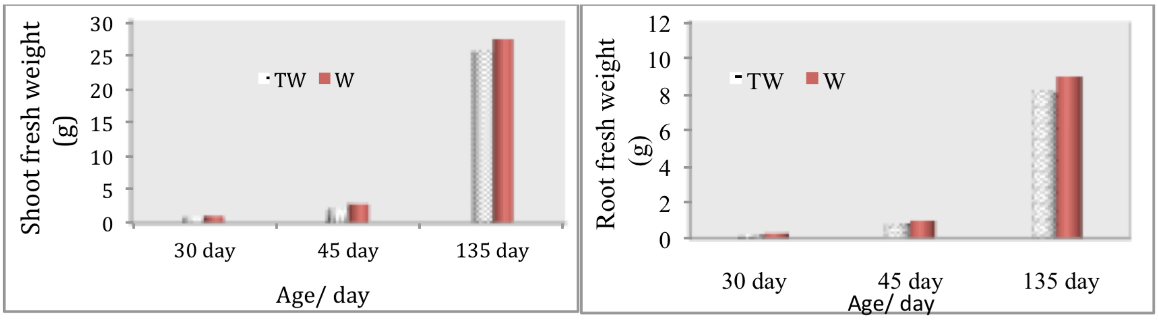


**Figure (2) :** The mean shoot and root fresh weights (g) of rice plants irrigated with treated (TW) and untreated (W) wastewater.

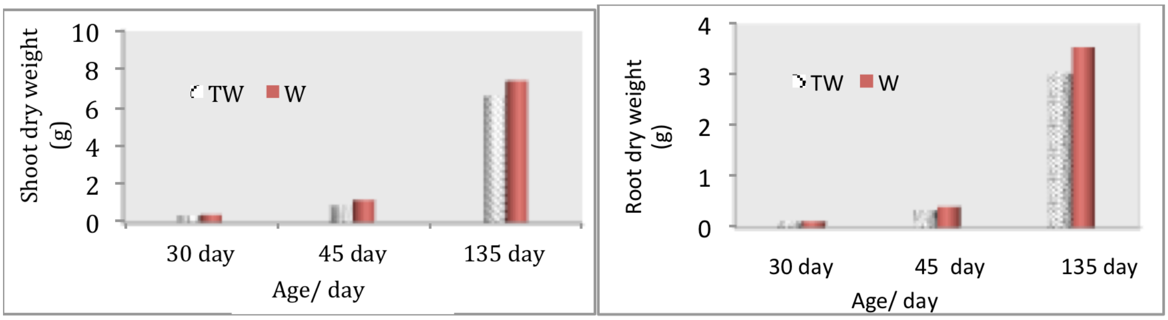


**Figure (3) :** The mean shoot and root dry weights (g) of rice plants irrigated with treated (TW) and untreated (W) wastewater.

### 4- Yield Characters

The yield characters of the rice plant were measured and statistically analyzed after harvest (Table 1a&b). Variation in heading dates was very small and not significant between W and TW irrigated plants. In TW, the mean value was after 86.7 days of plant age, while in W pots it was after 85.5 days. The retardation percentage of heading date between TW and W pots was only 0.23%.

**Panicle length, Panicles number per plant, grains number per panicle, 1000-grains weight and single plant yield.**

Results revealed that W plants acquired longer panicle, higher panicle number and higher grains number per panicle than that of TW plants. In plants of W pots the grains number per plant was 2098 grains, while in TW pots the grains number per plant was 2070 grains. Rice plants of this study varied significantly in the 1000-grains weight. In plant of W pots the mean weight of 1000-grains was 22.44 g, while in TW the mean weight was 21. 85 g. In W pots the mean yield of single plant was 43.25 g, while in TW it was 42.40 g. The variation percentages between the two treatments panicle length, panicles number per plant, grains number per panicle, grains number per plant, 1000-grains weight and single plant yield were 0.45%, 5.71%, 0.77%, 1.52%, 2.45 %, 1.96%, respectively.

**B-Cadmium and lead content**

**1-Cadmium and lead content in rice plant shoot, root, complete seeds and husk.**

Cadmium and lead contents of rice plant shoot and root were measured two times, after 45 and 135 days of plant age. After 45 days of plant age cadmium content was detected in shoot and root in treated wastewater irrigated plants (Fig. 4). From results of lead content it is notable that, plants of 45 days age contained higher lead content in both shoot and root (0.034 and 0.095 ppm). In non-treated wastewater irrigated rice plants (W), the cadmium and lead contents were much above that of treated wastewater irrigated (TW) rice plants. At 135 day of plant age (after harvest) cadmium and lead measurements were significantly different than that of the 45 days age plants. Root scored the highest cadmium content (0.024 ppm). Cadmium content was follow the following trend root > husk > complete seeds > shoot. Concerning to treated and untreated wastewater irrigated plants (Fig. 4), it is clear that the plants had low cadmium in comparison with lead content root and shoot cadmium. Lead content after 135 days of plant age was follow the following arrangement Root > shoot > complete seeds. Root scored the highest lead content. It is clear that all detected values in treated wastewater irrigated plants (TW) were below the permissible limit (see Fig. 4).

**Table (1a):** The mean yield characters of rice plants under the effect of irrigation with waste water (W) and treated waste water (TW).

| Characters | Treatments | Results | | | | | Mean |
|---|---|---|---|---|---|---|---|
| Heading date (day) | W | 84 | 86 | 87 | 86 | 85 | 85.5 |
| | TW | 88 | 87 | 85 | 85 | 86 | 85.7 |
| Paniclelength (cm) | W | 21.7 | 23.8 | 22.4 | 22.1 | 22.1 | 22.2 |
| | TW | 22.2 | 21.4 | 20.9 | 22.2 | 22.4 | 22.3 |
| Panicle no./plant | W | 19 | 18 | 17 | 16 | 19 | 17.5 |
| | TW | 19 | 16 | 17 | 17 | 16 | 16.5 |
| Grains no./ Panicle | W | 139 | 133 | 135 | 130 | 129 | 129.5 |
| | TW | 132 | 128 | 129 | 131 | 130 | 130.5 |
| Grains no./ plant | W | 2097 | 2101 | 2094 | 2100 | 2098 | 2099 |
| | TW | 2073 | 2068 | 2075 | 2065 | 2069 | 2067 |
| 1000-grain weight (g) | W | 22.7 | 22.7 | 21.9 | 22.5 | 22.3 | 22.4 |
| | TW | 21.6 | 21.8 | 22.4 | 21.5 | 22.2 | 21.85 |
| Single plant yield (g) | W | 42.8 | 42.9 | 42.3 | 43.6 | 42.9 | 43.25 |
| | TW | 42.6 | 42.5 | 42.6 | 42.2 | 42.6 | 42.4 |

**Table (1b):** The statistical analysis of the mean yield characters of rice plants under the effect of irrigation with waste water (W) and treated waste water (TW).

| | Source of variations | Sum of squares | df | Mean square | F | P |
|---|---|---|---|---|---|---|
| **Heading date** | **Between Groups** | 0.33 | 1 | 0.333 | 0.122 | 0.734 |
| | **Within Groups** | 27.33 | 10 | 2.733 | | |
| | **Total** | 27.67 | 11 | | | |
| Panicle length | Between Groups | 0.7 | 1 | 0.701 | 1.144 | 0.31 |
| | Within Groups | 6.13 | 10 | 0.613 | | |
| | Total | 6.83 | 11 | | | |
| Panicle no./plant | Between Groups | 1.92 | 1 | 1.92 | 1.5 | 0.249 |
| | Within Groups | 12.8 | 10 | 1.28 | | |
| | Total | 14.72 | 11 | | | |
| Grains no./ Panicle | Between Groups | 30.72 | 1 | 30.72 | 4.107 | 0.07 |
| | Within Groups | 74.8 | 10 | 7.48 | | |
| | Total | 105.52 | 11 | | | |
| Grains no./ plant | Between Groups | 2352 | 1 | 2352 | 163.333 | 0.00 |
| | Within Groups | 144 | 10 | 14.4 | | |
| | Total | 2496 | 11 | | | |
| 1000-grain weight | Between Groups | 0.81 | 1 | 0.806 | 7.474 | 0.021 |
| | Within Groups | 1.08 | 10 | 0.108 | | |
| | Total | 1.88 | 11 | | | |
| Single yield | Between Groups | 0.62 | 1 | 0.621 | 5.36 | 0.043 |
| | Within Groups | 1.16 | 10 | 0.116 | | |
| | Total | 1.78 | 11 | | | |

($P > 0.05$= non-significant and $P<0.05$= significant).

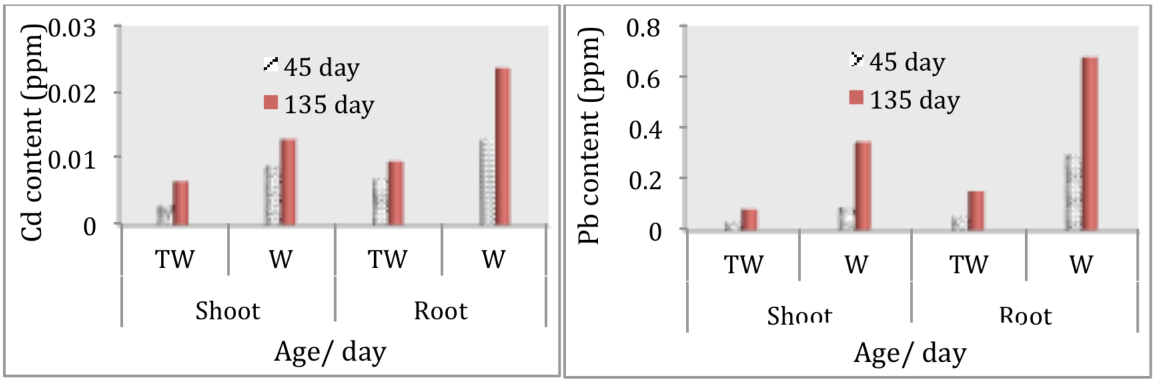


**Figure (4) :** The mean cadmium and lead concentrations (ppm) in rice plant shoot and root at 45 and 135 day of plant age.

**1.2-Cadmium and lead contents of soil**

Cadmium and lead contents in soil were measured to evaluate the effect of its irrigation with treated and untreated wastewater. Data were detected three times, before cultivation and at 45 and 135 days after rice cultivation and irrigation.

Figure (5) showed that, soil attained high contents of cadmium and lead by using non-treated wastewater in rice plant irrigation than by using treated wastewater. There are no difference in cadmium and lead content of soil before cultivation of rice plant, but After 45 day of plant age both of cadmium and lead content were elevated in non- treated wastewater irrigated soil.

At 135 day of plant age (after harvest) cadmium and lead measurements were significantly different than that of 45 days. By looking at treated wastewater irrigated soil, we notice that it had low cadmium and lead contents. Lead content after 135 days of plant age was much higher than cadmium.

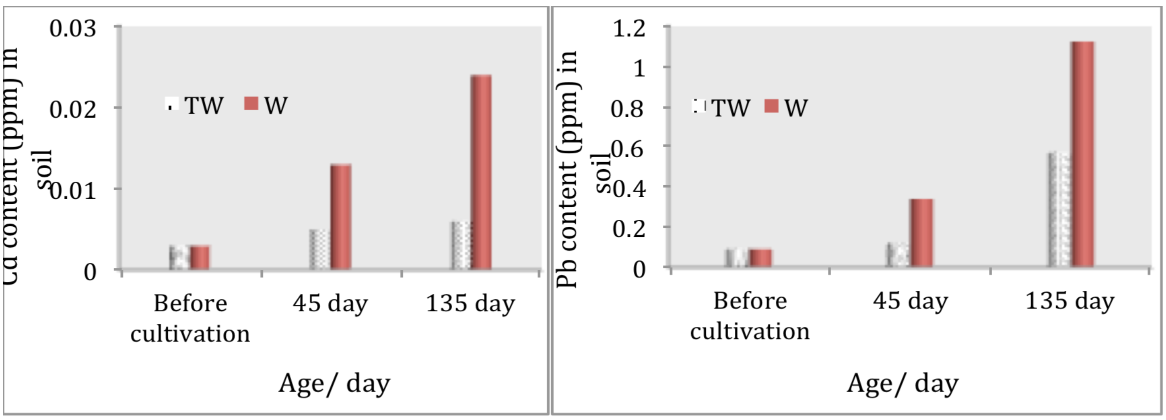


**Figure (5) :** The mean cadmium and lead content in soil, (before cultivation, after 45 and 135 day of rice plant cultivation).

## DISCUSSION

It is clear that, the shoot system of the studied rice cultivar was longer in wastewater irrigated pots (W) than in treated wastewater irrigated pots (TW). The root length showed that the rice cultivars attained longer roots in W pots than TW during the different growth stages. Furthermore, shoot and root fresh weights, shoot and root dry weights and the yield characters (panicle length, panicle number, grains number per panicle, grains number per plant, 1000 grains weight and yield/ per plant) increased also in wastewater irrigated plants. These results are in agreement with Yadav *et al.* (2014) who compared growth and development of rice plants irrigated by wastewater and normal well water, the average productivity of wastewater irrigated plants is higher than that of irrigated with well water. This due the fact that wastewater has high concentration of nitrogen, phosphorus, and organic matter in comparison to well water. Similar findings were also obtained by Ladwani *et al.* (2012) and with the data of Yadav *et al.* (2014) who studied the profitability of rice cultivation in the rural areas of Allahabad by wastewater irrigation from natural drainage. The wastewater containing organic nutrients attained higher profits than those using groundwater. Khai *et al.* (2008) stated that reuse of wastewater for irrigation caused an increase in total organic carbon content and total nitrogen in the soil. The soils that had received wastewater for irrigation had 1.68% total organic carbon and 0.19% total nitrogen.

Cadmium and lead contents in different rice plant organs and soil were measured to evaluate the effect of wastewater irrigation on soil rice plant cadmium and lead contents. Results showed elevation in cadmium and lead contents in W irrigated plants and soil cultivated in it, but the increase in lead content was much higher than that of cadmium. This agree also with Bakhtiarian (2001) who found that the use of contaminated water in the rice fields causes an increase in the lead and cadmium contents in the grains of rice and the consumption of this rice will enter the body of human. Yadav *et al.* (2014) studied the effects of wastewater irrigation on rice plants and reported that, the plants were negatively affected by the presence of heavy metals such as Fe, Mn, Cu, Zn, cd, Pb and Ni that are found in the water and soil. The soil along the sides of the wastewater channel shows higher concentration of heavy metals than the crops away to it, but lies within the safe limits of WHO/ FAO. A recent study by Nawaz *et al.* (2006) dealing with the effect of water containing heavy metals on yield components and heavy metal contents in paddy and straw of rice plant. This study showed contamination by the two heavy metals Cu and Cd to be within safe limits in the soil. Moreover, although they observed a minor accumulation of these metals in the plant parts, they found it to remain within the permissible limit. Yadav *et al.* (2014) menthioned that, the mean concentrations of heavy metals in the rice plant parts showed that most of the metals were accumulated in the roots than other plant parts.

Khai *et al.* (2008) compared long-term (30-50 years) wastewater-irrigated rice-dominated farming systems. He found that using wastewater for irrigation significantly affected pH, electrical conductivity, exchangeable K and

Na, copper (Cu), lead (Pb) and zinc (Zn) in the investigated areas compared with control plots irrigated using river water. Even if potential toxic elements in wastewater are not present in concentrations likely to directly affect humans and thus limit their agricultural use, they seem to be higher than in natural river water, which would contaminate the agricultural soils in the long-term. As a result, the concentrations of trace elements (Cu, Pb and Zn) in the wastewater-irrigated soils were significantly higher than in control soils, indicating that the application of wastewater had enriched the soil with trace metals.

On the other hand, (Zueng, 1989) found comparison of the mean lead content of the Gilan rice sample and mean difference of the Comfiroozi -Nedatypes was insignificant and the mean difference of the lead content was significant among the rest of the types of rice. Even though 88 percent of the cadmium and 70 percent of lead absorbed by the rice plant is accumulated in the roots and a small portion of them are stored in the grains.

Matsumura and Yamada (1975) stated that the main reason for higher lead and cadmium contents of rice plant is the great need of mineral element of the plant during the clustering period. On the other hand, the longer the drying time of the cereals before harvesting, the higher the rate of absorption and accumulation of the heavy metals in the grains of rice.

Chung *et al.* (2011) found that application of domestic wastewater to arable land significantly increased the levels of Pb, Cd, Cu, and Zn in soil and brown rice ($P < 0.01$). The concentration of heavy metals in brown rice were lower than the recommended tolerable levels proposed by the Joint FAO/WHO Expert Committee on Food Additives. However, the continuous monitoring and pollution control of hazardous materials from domestic wastewater are needed in order to prevent excessive build-up of heavy metals in the food chain and in aquatic ecosystems.

## REFERENCES

**Bakhtiarian, A.; Gholipour, M. and Ghazi-Khansari, M. (2001):** Lead and cadmium content of korbal rice in Northern Iran. Iranian J. Publ. Health. 30 (3-4): 129-132.

**Chung, B. Y.; Song, C.H.; Park, B. J. and Cho, J. Y. (2011):** Heavy metals in brown rice (*Oryza sativa*) and soil after long-term irrigation of wastewater discharged from domestic sewage treatment plants. Pedosphere. 21(5): 621-627.

**IRRI (International Rice Research Institute). 1989:** IRRI toward 2000 and beyond. Manila Philippine.

**Khai, N. M.; Tuan, P. T.; Vinh, N.C. and Oborn, I. (2008):** Effects of using wastewater as nutrient sources on soil chemical properties in peri-urban agricultural systems. VNU J. Sci., Earth Sciences. 24: 87- 95.

**Ladwani, K. D.; Ladwani, K. D.; Manik, V. S. and Ramteke, D. S. (2012):** Impact of domestic wastewater irrigation on soil properties and crop yield. Internat. J. Scientific and Research Publication. 2 (10).

**Matsumura, S. and Yamada, K. (1975):** Studies on the soil pollution caused by heavy metal, absorption of cadmium by leaves and leaves of rice plants. Gumma-ken Nogyo shikenjo Hokoku. 15:55-65.

**Maximous, N.; George, F.; and Wan, K. (2010):** Removal of Heavy Metals from Wastewater by Adsorption and Membrane Processes: a Comparative Study, World Academy of Science, Engineering and Technology, pp, 64.

**Nasim, A. K., Shaliza I. and Piarapakaran, S. (2004):** Review paper; Elimination of Heavy Metals from Wastewater Using Agricultural, Wastes as Adsorbents, Malaysian J. Sci., 23: 43 – 51.

**Nawaz, A.; Khurshid, K; Arif, M.S. and Ranjha, A.M. (2006):** Accumulation of heavy metals in soil and rice plant (*Oryza sativa* L.) irrigated with industrial effluents. Internat. J. Agri. and Biol. 8(3): 391-393.

**Said, A. G., (2010):** Biosorption of Pb (II) ions from aqueous solutions onto rice husk and its ash. J. Amer. Sci., 6 (10):143-150.

**Susuki, S. (1988a):** Daily intake of cadmium; an ecological view. In: Sumino's Environmental and occupational chemical hazards, Kishimote Publications & Print .8:205-17.

**Suzuki, S. (1988b):** Estimation of daily intake of cadmium from foods and drinks from faucets at three of kampungs of Java Island. In: Suzuki, S(Ed); Health Ecology in Indonesia.Goosey. Cotokyo. 65-73.

**Yadav, A.; Yadav, P. K.; Srivastava, S.; Singh, P. K.; Srivastava, V. and Shukla, D. N. (2014):** Profitability and health risk estimation of rice cultivation under wastewater irrigation from natural drainage. Internat. J. Scientific and Research Publications, 4(3):1-7.

**Zueng, S. (1989):** Cadmium and lead contamination of soils, rice plants, and surface water in Northern Taiwan. Soil and Fertilizers in Taiwan. 39-47.

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# الملخص العربى

## إستخدام مياة الصرف المعالجة بالفحم الحيوى لقشر حبوب الأرز فى رى وإنتاج نبات الأرز

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* قسم النبات – كلية العلوم – جامعة المنصورة
** مركـز البحـوث الزراعيـة – القاهـرة

تم إجراء هذه الدراسة فى الصوبة الزجاجية بمركز البحوث والتدريب فى الارز– سخا– كفرالشيخ ,خلال موسم زراعة الارز ٢٠١٢ (منتصف مايو حتى منتصف أكتوبر) لزراعة نبات الارز صنف جيزة ١٧٨ بإستخدام نوعين من مياه الرى:

أ– أصص تروى بمياه صرف *(W)*.

ب– أصص تروى بمياه صرف معامله *(TW)* بالفحم الحيوى الناتج من الحرق بمعزل عن الهواء لقشر حبوب الارز عند درجة حرارة ٥٠٠ درجة مئوية.

تم قياس دلالات النمو وإنتاجية الأرز أثناء مراحل النمو المختلفة ,وأوضحت النتائج أن نباتات الارز التى تم ريها بمياه صرف غير معالجة أكتسبت سيقاناً وجذوراً أكثر طولاً من تلك التى رويت بمياه صرف تم معالجتها وكان متوسط الزيادة فى طول الساق والجذر فى نهاية الموسم ٤,٥٢ ، ٩,٢٥٪ على التوالى.

كان الوزن الطازج لكل من السيقان والجذور أعلى عند الرى بمياه الصرف غير المعالجة مقارنة بالنباتات التى رويت بالمياه المعالجة. وكانت نسبة الزيادة فى طول الساق والجذر على التوالى عند نهاية الموسم حوالى ١٠,٦٥ ، ٩,٧٠٪ وكان الوزن الجاف لكل من السيقان والجذور هو الأعلى فى معاملة مياه الصرف غير المعالجة عنها فى المياه المعالجه وكانت نسبة الزيادة هى ١٠,٧٤ ، ٤,١٤٪ فى الساق والجذر على التوالى.

من حيث الصفات الإنتاجية لم يختلف الامر كثيرا حيث أظهرت النتائج أن الصفات الإنتاجية التى سجلت كان لجميعها قيما أعلى فى معاملة مياه الصرف غير المعالجة عنها فى مياه الصرف المعالجة وكانت نسبة الزيادة فى طول السنبلة ,عدد السنابل للنبات ,عدد الحبوب فى السنبلة ,عدد الحبوب فى النبات، وزن الألف حبة و محصول النبات الفردى كالأتى:٢,١٦ ، ٤,٤٩ ، ٢,٤٠ ، ١,٣٣ ، ١,٠٥٪ على الترتيب. أيضاً تم قياس محتوى الاجزاء المختلفة لنبات الارز والتربة المستخدمة من الكادميوم والرصاص وذلك لمعرفة تأثير الرى بمياه الصرف بدون معالجه بعوامل الادمصاص المختلفة على محتوى نبات الارز من الكادميوم والرصاص، أظهرت النتائج أرتفاع مستوى تلك العناصر فى اجزاء نبات الارز وايضا فى التربة وكان الارتفاع فى مستوى عنصر الرصاص أعلى بكثير من مستوى عنصر الكادميوم.

**JOESE 5**

# UTILIZATION OF WASTEWATER TREATED WITH RICE HUSK BIOCHAR FOR IRRIGATION AND PRODUCTION OF RICE PLANT

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