International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN: 0974-4290
Vol.8, No.11, pp 26-35,2015

Innovative Method to improve the Efficiency of Combined Wastewater Treatment Plant

Enas M. AbouTaleb[1], Ahmed Abd El-Aziz[2], Mahrashan Abdel Gawad[3], Alaa Abdel Aziz[2]and Mohamed Osama EL-Tawabty[4]

[1]National Research Centre, Water Pollution Control Department, El Buhous St, P.O. 12622, Dokki, Giza, Egypt..
[2, 4]Zoology Department, Faculty of Science, Al-Azher University. P.O. 11884, Nasr City Cairo, Egypt.
[3]Zoology Departments. Faculty of Science, Cairo University, P.O. 12613, Giza, Egypt.
[4] 6 October Wastewater Treatment Plant, P.O. 12573, Giza, Egypt.

Corresponding author: Enas M.AbouTaleb E .mail: enas_aboutaleb@hotmail.com

Abstract: Rice straw and luffa were evaluated as bio-sorbent filters to improve the efficiency of combined wastewater in 6 October Municipal Treatment Plant, which is located in a large industrial city, near Cairo. Rice straw and luffa were used as a tertiary treatment filter instead of sand filter. Due to its chemical composition, rice straw was more strength than luffa as a bio-sorbent filter. Using rice straw without any modification, the effluent quality showed that the COD and BOD removal improved by 98% with residual concentrations 20 mg O2 /l, 10 mg O2/l, respectively; heavy metals as micro pollutants were removed by 99% and the removal efficiency of total coliform bacteria reached to 98 %. Accordingly, rice straw was a good cheap bio-sorbent filter for many micro pollutants, and the produced effluent quality will be safe for usage in agricultural purposes to overcome the water scarcity which is one of the serious problems in Egypt now a days.
Keywords: Combined wastewater, treatment, micro pollutant, low cost, filter, rice straw, luffa.

Introduction

After few decades it is expected that, Egypt will face water starvation. Huge amount of industrial wastewater is directly discharged to the municipality. Extended industrialization trends in these new industrial areas and the development of new chemical products are generally associated with the increase in discharge of effluents which contaminated with organic and inorganic pollutants[1]**.** Treated wastewater is proposed as an important renewable water supply for using in irrigation. Moreover; it is contains nutrients that plants need as fertilizers. The conventional aerobic technologies based on activated sludge processes are dominantly applied for the treatment of domestic wastewater due to the high efficiency achieved, the possibility for nutrient removal and higher operational flexibility. Many industries produce wastewater containing macro and micro pollutant which discharged directly to governmental wastewater treatment plant. The direct discharge of industrial effluent into sewage networks produces disturbances in existing biological treatment processes. Nevertheless; the high capital and operational costs that coincide with the introduction of these technologies impose significant financial constraints on expansion. Therefore, to smooth the progress of sanitation services, reliable, unsophisticated and cost-effective treatment technologies should be adopted. Filtration is the purification process, whereby the water to be treated is passed through porous media. During this passage water quality improves by partial removal of suspended and colloidal matter by a reduction in the number of bacteria and other organisms and by changes in its chemical constituents[2]. Adsorption consists of the binding of molecules to the surface of an adsorbent, whereas absorption consists in the filling of the pores in the solid media. Usually both mechanisms take place in the treatment by filtration. The term sorption processes which both of adsorption and absorption mechanisms are working together[3,4,5]**.** Generally the chemical and physical structure properties of used filters have a great contribution in the wastewater treatment process. The chemical properties of all used agro-fibers is lignin as an integral part of the cell walls of the plants, lignin fills the spaces in the cell walls between cellulose and pectin components[6]**.**Agricultural by-product materials appear as effective and cheap sorbents for removal of heavy metals from wastewater. In Egypt; about 3.5 million tons of rice straw is produced**,** every autumn, a huge quantity of straw from rice cultivation is disposed of, traditionally by burning in situ, causing real environmental problems[7]**.** The removal of metal ions from effluents is important to many countries of the world, both environmentally and for water re-use. The sorption capacity of rice hull was more than sawdust[7-9]**.**The main objective in this study is to evaluate rice straw, luffa, as possible adsorbents for removal of zinc, cadmium and copper from combined wastewater (domestic and industrial).Furthermore, to get water complying with Egyptian Agriculture Code for safe irrigation.

Material and Methods

6 October Wastewater Treatment Plant

Wastewater treatment plant under investigation is located in; 6 October City which is the most important industrial city in Egypt.It has 1500 factories in 7 industrial zones. 35.3% of factories are highly polluted and 90% of these factories violate the environmental laws and don’t have any pre-treatment plants. 28.7% of factories have a moderate pollution load, while, 36% of factories have a low pollution load. 6 October Municipal Wastewater Treatment Plant received 150,000 m^3/day of raw wastewater. This subjected to conventional aerobic technology based on activated sludge followed by a tertiary treatment.

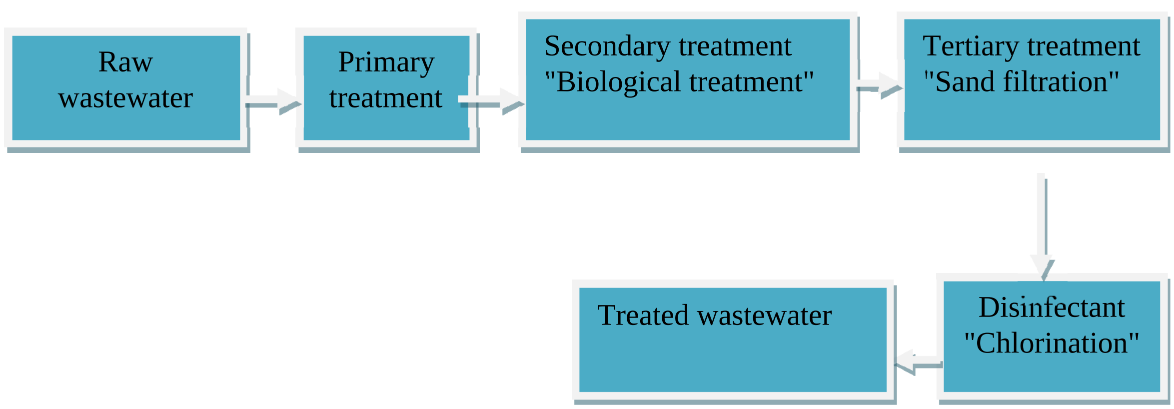


Fig.(1): Schematic diagram illustrates the treatment process in 6 October wastewater treatment plant

1- The semi pilot experiment

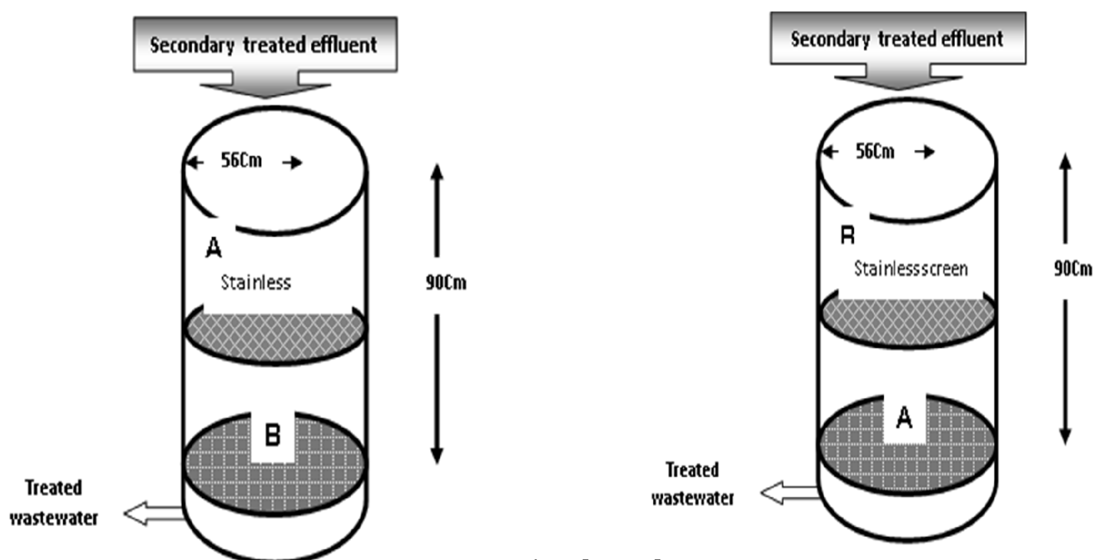
Design and manufacture semi pilot experimental set consist of 2 barrels of the same size, the barrel volume was 221 litter, its length 90 cm and diameter56 cm. Each barrel divided into two compartments, the first barrel was filled with (A) luffa and then (B) rice straw and the second was filled with (B) rice straw and then (A) luffa (Fig2). The quality of the treated water was evaluated in each case. The removal efficiency of the two bio-sorbents; rice straw and luffa in a semi pilot cell for removing heavy metals, phenols , microorganisms and..…etc. was evaluated, too.

a- Effect of bio- sorbent type

The removal efficiency of micro pollutants using bed filter of luffa and rice straw was investigated to evaluate the treatment efficiency of each sorbent. Luffa which is dried fruit of luffa sponge guard plant, is composed of 60% cellulose, 30% hemicelluloses and 10% lignin; present as a cell circle structure. Whereas, rice straw is produced as a by-product during rice processing [6]. It's composed of 28-48 % cellulose, 26.40% hemicelluloses and lignin; presented as cell wall structure, 12.26% ash, 2.18% wax and 9% silica [6].

B-Effect of bio- sorbent order

The combination of rice straw and luffa in two different orders was investigated to evaluate the treatment efficiency in each case (Fig.2).



First barrel

Second barrel

A= luffa **B**= rice straw

Fig.(2):Schematic diagram represent the semi pilot experimental set

11-The pilot experiment

The proposed project required some modifications on the plant; all modifications were carried out on 6 October Wastewater Treatment Plant. The implementation was designed in a series of stages.

The modified sand filter bed (Fig.3a&b)

- Dimension of the filter bed was 6.2 ×8.0 ×2.8 m.
- It consisted of 32 PVC pipes × length 2.5 with pores 10 ml.
- Dimension of the rice straw block was 1.5 ×60 × 50 cm, the block was placed instead of sand filter.
- Iron rods (coated with paints against rust) were placed on the surface of the rice straw filter to prevent its floating.

- The effluent of water from secondary treatment to inlet the rice straw filter passed through a telescope trap, water quantity influent was equal to 5.000 m^3 /day and retention time was 40 minutes.
- Samples for required analyses were collected from effluent rice straw filter after treatment.

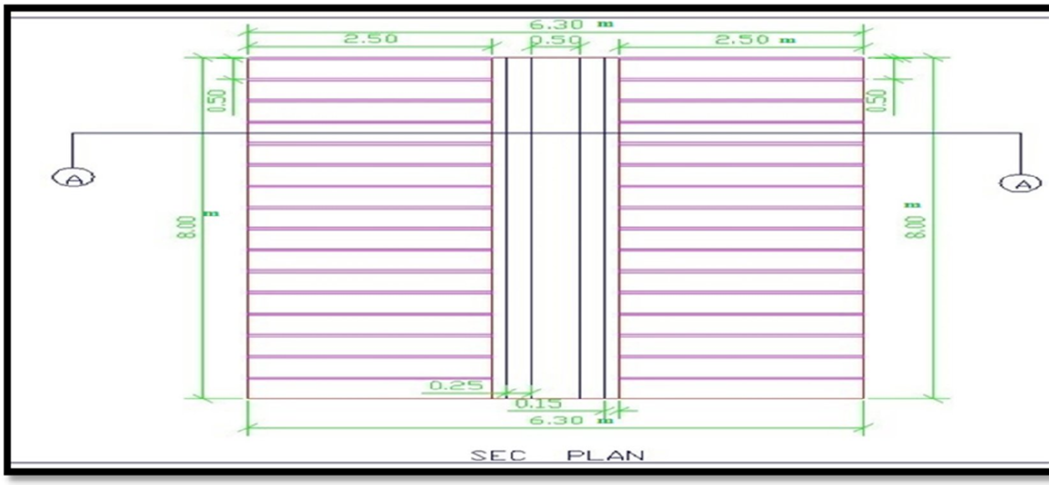


Fig.(3) a: Schematic diagram of the modified sand filter bed

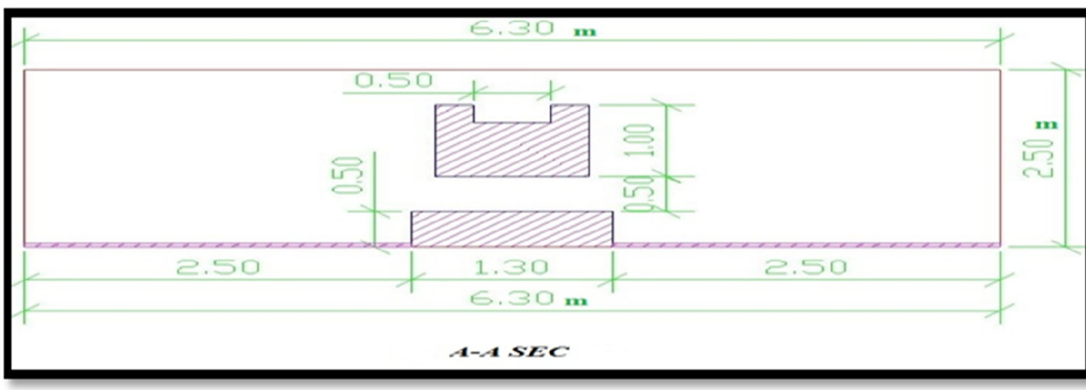


Fig. (3)b: Cross-section of (fig3)a

a-Wastewater samples collection

Due to the great variations in the quality of wastewater from different factories during the working day, a continuous monitoring program was carried out to identify quality of the discharged wastewater. Wastewater samples were daily collected for one weak from inlet of the wastewater treatment plant and from outlets of the secondary treatment and rice straw filter.

b- Physico-chemical and biological analyses

Composite samples were collected during the work, then, were subjected to physico-chemical analyses according to "Standard Methods for Water and Wastewater" [10]. The analyses included pH, color, total suspended solids (TSS), settleable solids, chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease, total sulfide (H_2S), , heavy metals and scanning microbial, faecal coliform (FC) and total coliform (TC).

c- SEM, microscopic study and analysis of rice straw

Scanning electron microscopic (SEM) study for rice straw structure before and after using in the treatment process in the study was done. The used rice straw was also analyzed for heavy metals and micro pollutants. Furthermore, wet and completely dried of the used rice straw were carefully examined microscopically for pathogens.

Results and Discussion

Characterization of influent wastewater

The characteristics of influent to the Municipal Wastewater Treatment Plant and the effluent wastewater produced from secondary treatment were depicted (Fig 4) and Table (1). The results indicated that organic loading rate varied during the period of study as the COD and BOD concentrations varied between the plant influent and the secondary treatment effluent

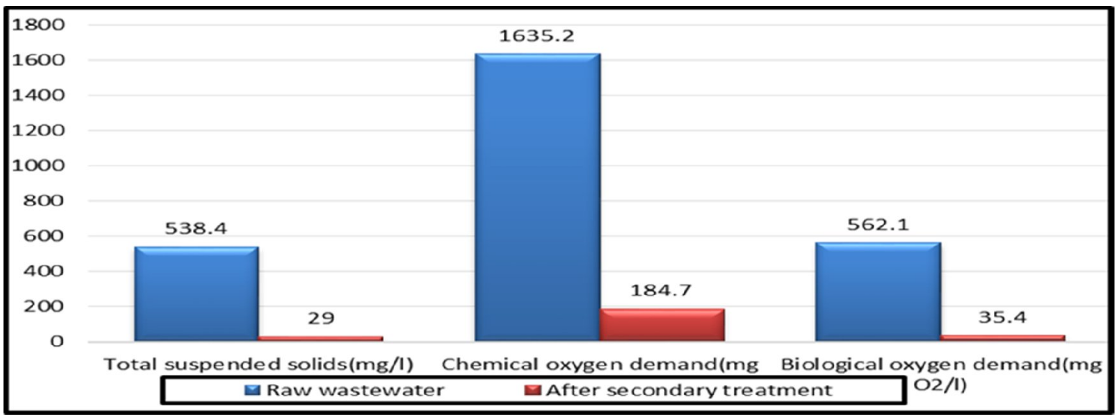


Fig. (4): The characteristics of raw wastewater and outlet wastewater after secondary treatment.

Table (1): The characteristics of raw wastewater and outlet wastewater after secondary treatment

Average 45 samples

Parameters	*Inlet(raw wastewater)*			*Outlet (after secondary treatment)*		
	Min	**Max**	**Average**	**Min**	**Max**	**Average**
Total suspended solids(mg/l)	267	733	538.4	18	43	29
Chemical oxygen demand(mg O_2/l)	1056	2315	1635.2	100	305	184.7
Biological oxygen demand(mg O_2/l)	377	703	562.1	12.6	59	35.4
Lead(mg/l)	1.2	3.5	2.2	0.9	1.8	1.3
Chromium (mg/l)	0.5	1.9	1.1	0.05	1.0	0.72
Total coliform (MPN/100 ml)	1.2×10^5	2.3×10^7	1.5×10^6	1.2×10^3	1.1×10^4	0.8×10^3

1-The semi pilot experiment

A-Effect of bio-sorbent type

The two barrels were filled with agricultural packing material; the first barrel filled with luffa, while the second filled with rice straw. The secondary treated wastewater was fed to each barrel and effluents were examined and evaluated during the course of study. The integrated filtration system was operated at the operating condition. Figs (5-7) summarized the comparison between the percentage removal efficiency of rice straw and luffa as different bio- sorbents for removing organic loads represented in COD, BOD and suspended solids.

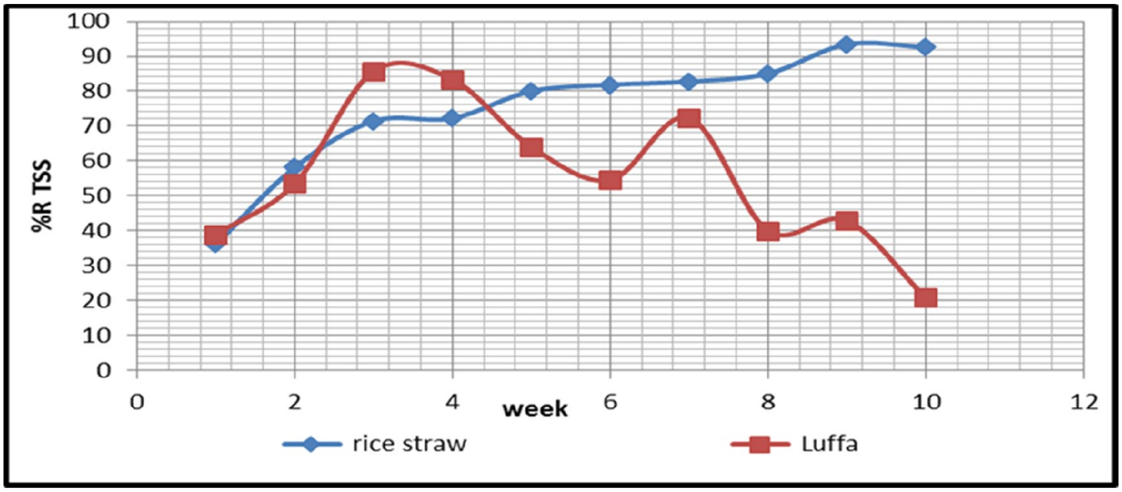


Fig.(5): Comparison between removal efficiency of rice straw and luffa for TSS.

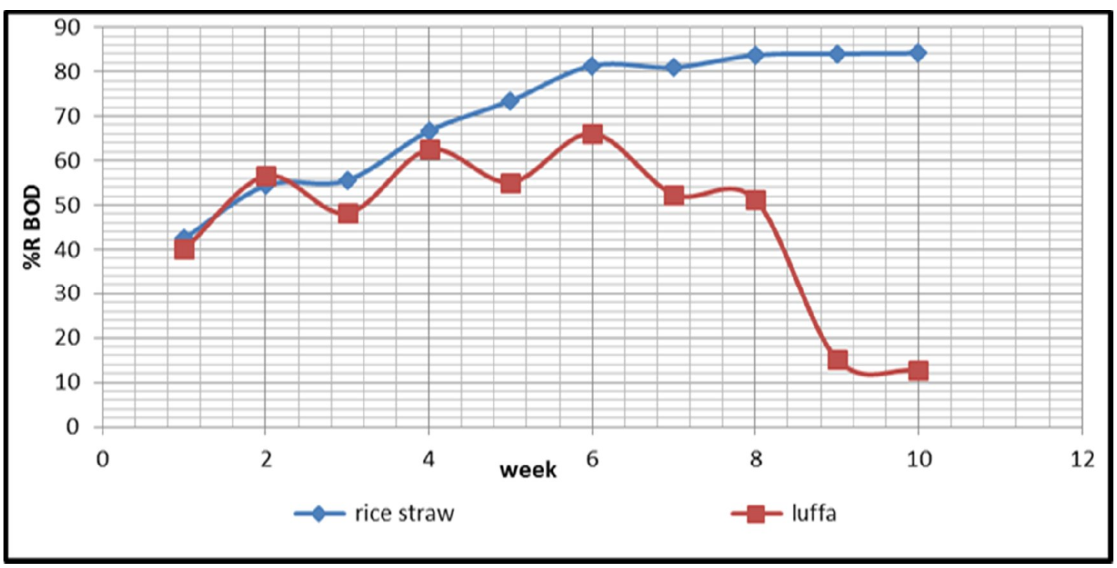


Fig.(6): Comparison between removal efficiency of rice straw and luffa for BOD

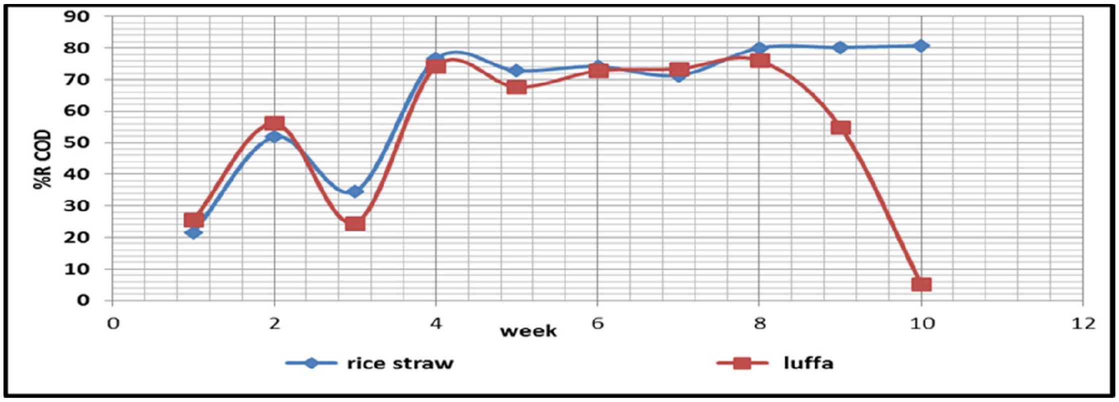


Fig.(7): Comparison between removal efficiency of rice straw and luffa for COD.

The results showed that, the reduction of organic load after passing through the rice straw barrel increased gradually. Rice straw was more effective for organic loads removal and suspended solid than luffa after 10 weeks. Luffa dissociates faster than rice straw due to the chemical composition of rice straw which has 9% silica which makes rice straw more strength than Luffa as a sorbent[10,11].

B-Effect of bio-sorbent order

Combination of rice straw and luffa in the two different orders was used to improve the treatment efficiency. Two semi pilot experimental sets consisted of two barrels of the same volume, each barrel divided into two compartments were prepared. First one was filled with luffa in upper compartment and rice straw in the lower one. The order of the two sorbents was reversed in the second barrel. Comparisons between the two cases were shown (Table 2).

Table (2): Effect of order of the two bio-sorbents on removal efficiency

Parameters	**Rice straw / luffa**	**Luffa / rice straw**
Total suspended solids	80%	62%
Chemical oxygen demand	70%	56%
Biological oxygen demand	65%	45%

*Average % removal for 10 samples

The results prove that the order of bio sorbent; rice straw then luffa give more efficient in removal of organic load. These results were attributed to the chemical structure of rice straw which has (5-24%) lignin. The lignin is promptly available to interact with cations, by firstly exchanging with protons[12].Which make the second layer (Luffa) act as polishing sorbent. However; luffa in first layer was decompose faster than Rice Straw and it produce suspended solids and tissue which raise the organic load in the treated effluent. From previous results rice straw selected as a bio-sorbent used in pilot plant experiment.

11-The pilot experiment

Rice Straw composed of cellulose, hemicelluloses and lignin as the main constituents. Also; it contains lipids proteins simple sugars starch hydrocarbons which contains a variety of functional groups present in the binding process.[13]. The functional groups present in bio sorbent molecules include acetamid, carbonyl, phenol group, amino, ester,…etc[14].These groups have the affinity for metal complex[15] The current results obtained Fig.(10) illustrated that the usage of rice straw as a bio-sorbent in the pilot plant raised the removal efficiency of Total Heavy metals reached to 99 % with residual concentrations less than the permissible limits in the National Legislation.

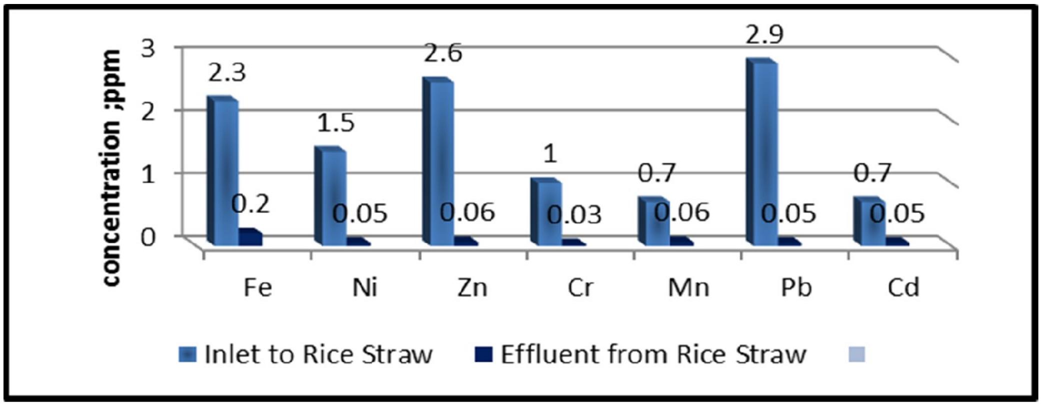


Fig.(8) : Residual concentration of heavy metals after using rice straw filter.

To clarify the efficiency between existing sand filter and rice straw filter bed a comparison between the final effluent resulted from each filter was carried out. The results (Fig. 9) showed that the rice straw filter was more efficient than sand filter due to the presence of various functional groups and the complexes that formed with heavy metals during bio-sorption process[16].

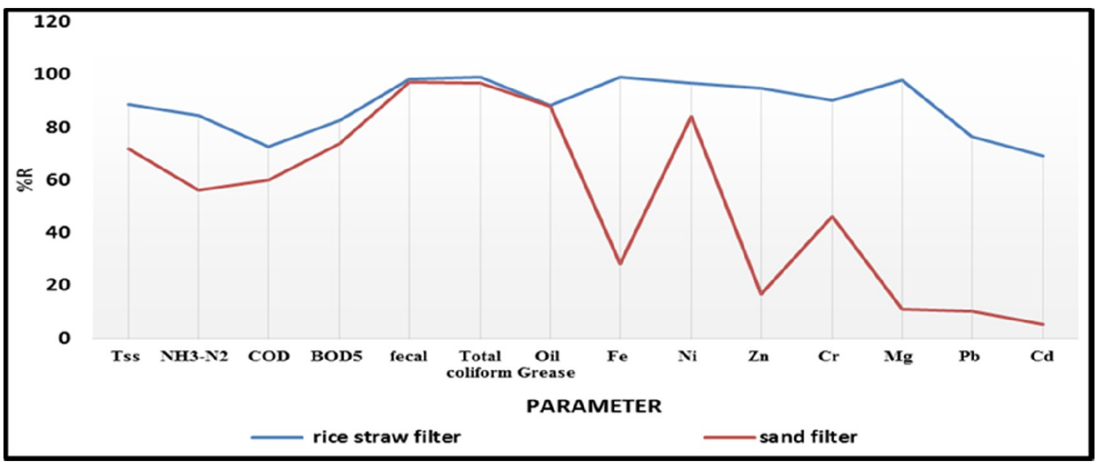


Fig.(9) : Comparison between overall efficiency of rice straw and sand filters.

SEM study of rice straw structure

Scanning electron microscopy (SEM) was used to reveal the interior structure of rice straw before (=raw) and after using for 50 days as shown in Figs. (10 a & b).

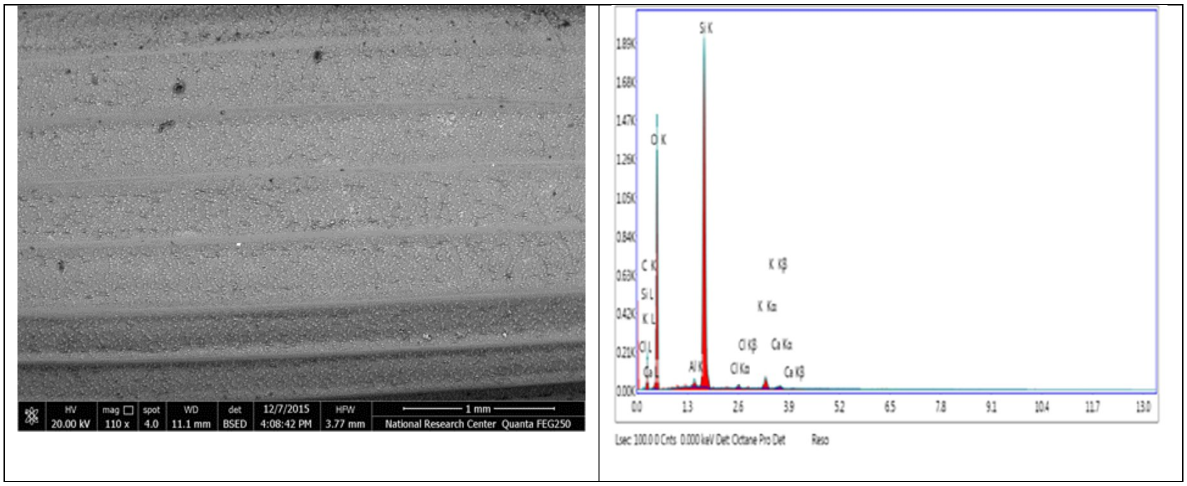


Fig.10. a Electron microscope (spectrum 1) Raw Rice Straw

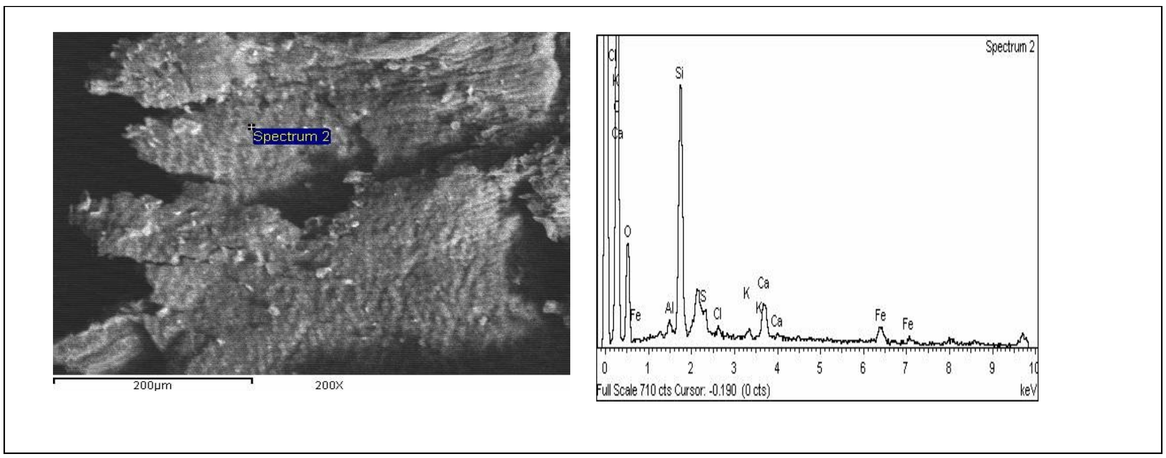


Fig.(10).b : Scaninng electron microscopy (spectrum 2) of rice straw after using for 50 days.

Rice straw/analysis for heavy metals

Table (3) and Figure (11) illustrated the metal analysis of dried rice straw after using for 50 days. It was obvious that the interior structure of rice straw played an important role in water treatment. This was attributed to its insolubility behaviour in water, moreover; it had a good chemical stability, high mechanical strength and had a granular structure to become a good bio-sorbent for removing heavy metals from wastewater.

Table (3): Analysis of absorbed heavy metals in rice straw filter

Metal ions	**Fe**	**Ni**	**Zn**	**Cr**	**Mn**	**Pb**	**Cd**
Concentration (mg/kg)	**925**	**293**	**5845**	**150**	**83.45**	**3575**	**80**

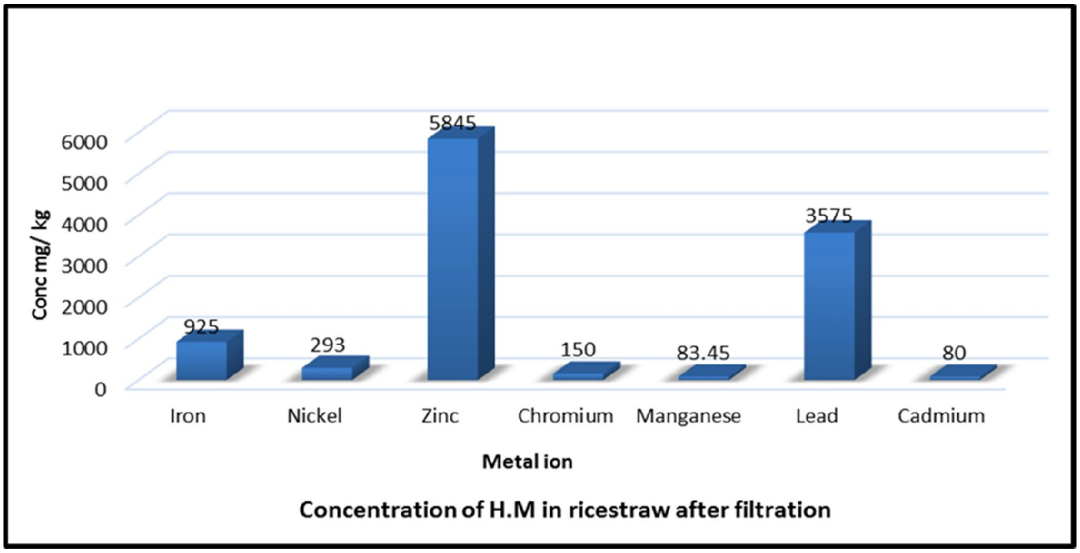


Fig.(11) : Concentration of absorbed heavy metals (H.M.) in rice straw after filtration.

Microscopic study of wet and dry rice straw

Wet rice straw after using for 50 days in the experiment was carefully examined microscopically. Pathogens could be expelled from wastewater because of their adsorption character to organic solids or dormant rice straw through its pores. These pathogens were, for example, nematodes, rotifers, protozoans and…etc. After complete drying of rice straw, almost all these pathogens were died. However, further investigations are demandable to determine the optimum operating condition for saving disposal of the used rice straw.

CONCLUSION

Rice straw is a good, cheap bio-filter, having a higher efficiency for micro pollutants than sand filter as a tertiary treatment by comparing between the effluents from them. Moreover, the effluent after rice straw filter consumes very small dosage of chorine as a disinfectant due to its high removal efficacy against micro-organisms.

ACKNOWLEDGEMENT

The authors would like to express their deep thanks and grateful appreciations to **Eng. Ahmed Zaki Abd El Aziz,** General Manager of 6th October Wastewater Treatment Plant for using all the facilities of the plant during the course of study and for his helps. Many thanks are also, due to **the working staff** in the same treatment plant for their great helps during the period of research.

REFERENCES

1. **World Health Organization"WHO" and UNICIF (2011)**; Joint Monitoring Programme for Water Supply and Sanitation. Coverage Estimates Improved Drinking Water. Usage of some agricultural by products in the removal of some heavy metals from industrial wastewater.
2. **Celik, A. and Demirbas, A. (2005):** Removal of heavy metal Ions from aqueous solutions via adsorption onto modified lignin from pulping wastes. Energy Sources. 27, 1167-1177.
3. **Annadurai, G., Juang, R. S., and Lee, D.L. (2002)**: Adsorption of heavy metals from water using banana and orange peels". Water Sci.Tech.47, 185-190.

4. **Li, Q., Zhai, J., Zhang, W., Wang, M. and Zhou, J. (2007):** Kinetic studies of adsorption of Pb(II),Cr(III)and Cu(II) from aqueous solution by sawdust and modified peanut husk. J. Hazard. Mater.141, 163-167.
5. **Sud, S., Mahajan, G., and Kaur, M. P.(2008**): Agricultural waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions: a review. Bio-resource Tech.99, 6017-6027.
6. **Shaban, A. M.; M. M. Kamel, N. Kenawy and Hala Elmanakhly (2009):** Role of interior structure of agro and non-agro materials for industrial wastewater treatment. J. App. Sci. Res. 5,978-985.
7. **Abd Elsalam. M, and El-Naggar H (2010):** In-plantcontrol for water minimization and wastewater reuse: a case study in pasta plants of Alexandria flour mills and Bakeries Company. Egypt. J. Clean Prod. 18, 1403–1412.
8. **Hanan E. Osman, Reham K. Badawy, Hanan F. Ahmed (2010**): Removal of Copper from Simulated Wastewater Using Pongamia Pinnata Seed Shell as Adsorbent. J. Phytology 2,51-62
9. **Goyal, P., Sharma, P, Srivastava, S. and Srivastava, M. M (2008***)*: *Saraca indica* leaf powder for decontamination of Pb: removal, recovery, adsorbent characterization and equilibrium modelling. International J. Environ. Sci. and Tech. 5, 27-34
10. **APHA (2005):** American Public Health Association, recognizing the need for standard methods in the bacteriological examination of water, sponsored a convention of bacteriologists to discuss the problem Standard Methods for the Examination of Water and Wastewater 16th Edition, APHA.
11. **Beveridge, T.J., and Murry, R.G.E. (1980):** Sites of metal-deposition in the cell wall of *Bacillus subtilis.* J. Bacteriology 141, 876–887.
12. **Gupta, V.K., and I. Ali. (2000**): Utilization of bagasse fly ash (a sugar industry waste) for the removal of copper and zinc from wastewater. Separation and Purification Technology 18, 131–140.
13. **Saha, B.C. (2003):** Hemicellulose bioconversion. J. Indus. Micro. Biotech. 30, 279- 291
14. **Sud, D., Mahajan, G., and Kaur, M. P. (2008):** Agricultural waste material as potential adsorbent for sequestering heavymetal ions from aqueous solutions a review. Biores. Tech. 99, 6017–6027.
15. **Garg, U.K. Kaur, M.P. and Garg, V.K. (2008):** Removal of nickel (II) from aqueous solution by adsorption on agricultural waste biomass using a response surface methodological approach, Bio resource. Technol. 99, 1325–1331.
16. **Gupta, V. K. and Ali, I. (2000):** Utilization of bagasse fly ash (a sugar industry waste) for the removal of copper and zinc from wastewater, Sep. Purif. Tech. 18, 131–140.C.R.T. Tarley, S.L.C. Ferreira.

*****