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EFFECTS OF WATER HYACINTH *EICHHORNIA CARSSIPES* CULTIVATION IN FISH POND ON HEAVY METAL ACCUMULATION IN SOIL

IBRAHIM M. SH. ABD EL-FATTAH

Central Laboratory for Aquaculture Research, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt.

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Abstract

The effect of water hyacinth "*Eichhornia carssipes*" cultivation in earthen ponds on reducing the soluble heavy metals (Fe, Mn, Cu, Zn, B, Cd and Pb) contents in sewage waste water, soil surface and subsurface layer and in fish (tilapia, *Oreochromis niloticus*) and (mullt, *Mugil cephalus*) was studied in an investigation for 150 days period. The investigation was carried out at Shader Azzam, Port Saied Governorate. Results showed that, the average concentration of heavy metals in sewage wastewater significantly decreased with the increasing water hyacinth cultivation in ponds. Also, the accumulations of heavy metals in soil layers were significantly decreased with increasing cultivation rate of water hyacinth cultivation. Cultivating water hyacinth in fish pond at 10 and15% resulted in higher reduction of heavy metals in water, soils layers and fish bodies with high production of fish.

INTRODUCTION

Fish culture in Egypt has an important role in producing great quantities of fish as a source protein which compensate the shortage in meat production. Therefore, the area of fish farms has reached 140000 feddan. It is necessary to save huge quantities of Nile water for fish farms and because of the unavailability of good water and the competition between agriculture and aquaculture for water, a Republican Decree has been issued to prevent using Nile water for fish culture. Therefore, it has been necessary to find another available source of water. Repots of Drainage Research Institute have estimated the discharged quantities of drainage water in Egypt by 10-15 milliards cubic meters annually and 8-10 milliards cubic meters sewage wastewater annually. This pays the attention to the capability of making use of drainage water whether in its status or after mixing with Nile water for utilizing it in fish farms, instead of being lost without any effects on soil and fish.

There is an increasing need for additional water resources to meet the demands of the new land reclamation project in Egypt. Drainage water could be readily available source of water for irrigation. The Ministry of irrigation estimated the total annual discharge of drainage water in Egypt by more than 10-12 billion cubic meters. Most of this water is presently discharged of in the Mediterranean Sea and the northern lakes.

The findings of El-Nahal *et al.* (1983) showed that the water of Bahr El-Baqar drain amounting to more than 359.5 million cubic meters annually which would be enough to irrigate about 36000 feddans. Also, they added the water of Bahr El-Baqar drain contain less than 1000 ppm salinity and its that SAR value is low throughout the year and can therefore be used directly for irrigation without any significant effects on soil.

In some regions of Egypt, where there is a shortage in fresh water, fish are cultured in some private farms using untreated sewage waste water and agriculture drainage water. These waters may cause a potential health risk to handlers and consumers of such fish (Lawton and Morse, 1980). For this reason, the use of wastewater effluent for aquaculture has not yet been approved by health authorities.

According to Sandbank and Nupen (1984) the largest problem regarding aquaculture in wastewater effluent, is the accumulation of heavy metals, pathogens and pesticides in the fish and as a result, the possible transmission of diseases to man.

Usually, 65-90% of the organic matter in wastewater is colloidal or particulate. Consequently a reduction in the same removal range can be obtained with chemical and biological treatment of raw wastewater. In future, the focus will be more on heavy metals, organic micro-pollutants and bacteria and viruses as pollutants

Aquatic weeds can be used to partially strip traces of potentially harmful or odorous agents from drinking water including cadmium, nickel, mercury, phenol and potential carcinogens. The aquatic plants remove and concentrate these elements, which may become 400-2000 times more concentrated in the plants than in the water (Noel, 1976). He added that, not all aquatic plants are equally adapted for growing on waste waters. Many of those that seem to grow best are common weeds, for example, the common reed, bulrush, water hyacinth, duck weeds, forms of elodea and hydrilla.

Water hyacinths, these floating plants, will remove nutrients from the water and reduce phytoplankton production. In recent studies at Auburn University, water hyacinths were stocked in earthen ponds at rates of 0, 5, 10 and 15% of surface area (Smitherman and Boyd, 1974).

Satyakala and Jamil (1992) reported that the surface water weeds like water hyacinth and water lettuce have been shown to have great potential as biological filters for absorbing pollutants including heavy metals from waste water.

The prime objective of this study was to:- 1- Prepare base line data on the use of water hyacinth as a biological filter for sewage wastewater in earthen ponds. 2- Effect of water hyacinth cultivation in ponds on accumulation of heavy metals in soil, water and fish.

MATERIALS AND METHODS

Water hyacinth *(Eichhornia carssipes)* was collected and maintained in earthen ponds as stock culture. Plants were selected from the stock culture for experimental purpose with approximately of the same size and weight (50.0±2.6g) for each plant.

The present study was carried out in fifteen earthen pond each of (400m^2 area) at Shader Azzam region, south of Port Saied Governorate, Egypt, which is under surface irrigation by using sewage wastewater from Bahr El-Baqar drain. Thereafter, the earthen ponds were divided randomly into 5 treatments with three replicates each. The treatments applied were wastewater without water hyacinth "control" and other treatments were 5, 10, 15and 20% cultivation ratios of water hyacinth in ponds.

The ponds were of the same area 400m^2 each with an approximately average depth of 1.40m. For all ponds the water level was maintained at a depth of 100cm, all ponds were stocked with two species of fish, Nile tilapia *(Oreochromis niloticus)* and Grey Mullt *(Mugil cephalus)*at a ratio of 1:1. Both fish species were stocked in the ponds at a density of 2 fish/ m^3. The average fish weight at the experimental start were 10.0±1.5 and 15.0± 2.1 g for tilapia and mullt respectively. Thereafter, water hyacinth was cultivated in ponds at the experimental rates.

Column sampler took Complex water samples for chemical and biological analysis monthly were obtained using a Column sampler. Each water sample was collected from five spots in each experimental pond.

Soil samples were collected from the bottom of each pond for the layers of 0-20 and 20-40 cm depth before and after cultivation. Samples were air dried, crushed, sieved through a 2 mm sieve and kept in polyethylene bags for analysis.

Methods of water and soil analysis

Chemical and biological water analysis

pH-value was determined using pH meter model 345. Salinity was measured by conductivity meter model YSI 33 S.C.T. meter. Temperature and dissolved oxygen D.O were measured using oxygen water model YSI 57. Total ammonia (NH_4); nitrate (NO_3); total nitrogen (T.N); total alkalinity T.alk.; total hardness T.H; Total phosphorus T.P. and Orthophosphate O.P. were measured according to the methods described by A.P.H.A. (1995). The heavy metals (Fe, Mn, Zn, Cu, B, Cd and Pb) concentrations in water were estimated following the method of A.P.H.A. (1995).

Soil physical and chemical properties

Particle size distribution was determined by the pipette method (Piper, 1950) using sodium hexa-meta-phosphate as a dispersing agent. pH; organic matter (O.M.)%; electrical conductivity (E.C); calcium (Ca); magnesium (Mg); sodium Na; potassium (K); cation exchange capacity (CEC); carbonate (CO3); bicarbonate (HCO3); chloride (Cl) and available macronutrient N, P, K were measured according to Black (1965).

Soluble sulfate was calculated by subtracting the total soluble anions from the total soluble cations.

Microelements in soil were extracted by DTPA using developed method and their amounts were determined by the atomic absorption (Black 1965).

Plant analysis

Plant samples after washing by deionized water were dried at 60°C to constant mass then ground to powder with a stainless steel tissue homogenizer.

Samples were predigested in nitric acid overnight and then digested in hot nitric acid/ perchloric acid (5/1: v/v) for about 6h. All analysis were performed using a GBC 906 AA flame atomic absorption spectrophotometer (A.P.H.A. 1995).

Statistical analysis was conducted foiiowing Snedecor and Cochran (1971), and Duncans (1955) multiple range test was applied to test the significances among the means.

RESULTS AND DISCUSSION

Effects of water hyacinth cultivation in ponds on soil particle size distribution

The obtained data for soil partical size distubution are presented in Tables(1&2). The data indicated that the clay content decreased with depth in most soil profiles, while the content of sand increased by fish culture.

The changes of sand content for all treatments were sharply decreased in surface layer but were slightly decreased in subsurface layer. These decreases of sand content are most probably due to the increase of silt and clay content.

The silt content for all treatments sharply increased in surface and slightly increased in subsurface layers for soil samples before and after cultivation. These results are in agreement with those obtained by Daniels (1989) and Shaker (1998).They reported that the silt and clay content increased but sand content decreased for fish farm before and after experiment.

Generally, the changes of sand in the first treatment "control" were 17.37 and 4.42% in surface and subsurface layer but in other treatments were 15.84, 13.81, 14.39 and 13.37 for 5, 10, 15 and 20% respectively in surface layer while in subsurface layer were 3.73, 3.26, 4.03 and 4.99 for the same treatments respectively. From the above data, the changes of sand content in the control treatment was higher than other treatments. The difference between control and other trreatments may be due to the cultivation of water hyacinth in these treatments.

Effect of water hyacinth cultivation in ponds on soil chemical properties

According to the obtained data presented in Tables (3 & 4) it could be noticed that there is a wide variation in the soil pH and organic matter content (OM) of the soil under this study.

The O.M% (organic matter) in all treatments increased after applaying the experimental treatments, this increase may be due to the relatively high organic compounds content in sewage wastewater.

The data indicated that the O.M% content decreased with depth in most soil profiles. Also, it was high in the control treatment without water hyacinth than other treatments.

In general, the increase of organic matter content "change in organic matter" was significantly highest ($P<0.01$) in control treatment and first treatment. And the increase of O.M content in surface layer was higher than the increase in subsurface layer; this increase may be due to the accumulation of organic compounds in surface layer.

Also, the changes in O.M content in surface and subsurface layer in treatments 15 and 20% cultivation with water hyacinth in ponds did not differ significantly between before and after harvesting, these results are in agreement with those obtained by Shaker (1998).

The obtained data for EC in Table (3&4) showed that the electrical conductivity of all layers increased after fish harvesting. Values of EC for all treatments were slightly increased in surface and subsurface layers. The increase in EC is certainly depends on the conductivity of the used water, the rate of irrigation and drainage condition of ponds and aquaculture system of ponds. These results are in agreement with those obtained by Daniels (1989); El-Nagdi and Shaker (1997) who reported that the increase of EC in soil profile reefers to the use of drainage water in irrigation.

As shown in Table (3&4) the amount of soluble cations Ca, Mg, Na and K increased in all treatments after cultivation. The increase of soluble ions concentration after the experiment may be due to: high concentration of these ions in sewage water,

water evaporation from ponds and type of management for ponds.

Overall, the changes of Ca, Mg, Na and K concentration in control treatment was higher than other treatments. These results may be due to the cultivation of water hyacinth in these treatments. Generally, the soluble cations increased after utilization of the soil as a fish culture. These results are in agreement with those obtained by Daniels (1989) and El-Nagdi and Shaker (1997) who reported that the concentration of soluble cations in surface and subsurface soil increased after fish culture in these ponds.

On the other hand, the soluble anions increased after fish harvested in all treatments. The increase of bicarbonate in soil after fish harvest may be due to the biological activity in the soil in presence of moisture content.

Data of available macro nutrients in Table (3&4) indicate that there was an increase in soil nitrogen, phosphorus and potassium after conducting the experiment treatments.

Overall, the increase of total and available nitrogen may be due to the increase of organic compounds, (feed; organic fertilizer; phytoplankton; zooplankton and waste of fish) in soil and the increase of the biological activity of fish. The increase of total nitrogen, available nitrogen and available phosphorus in soil may be due to the application of inorganic fertilization including P, N and organic matter which caused an increase in solubility of phosphate as results of decrease in pH caused by accumulation of CO3. These results are in agreement with El-Nagdi and Shaker (1997), who reported that the utilization of land in fish farming increased available phosphorus and nitrogen.

The cation exchange capacity (CEC) of the investigated soil generally increased as a result of fish cultivation. Such type of land use certainly implies an increase in organic matter and consequently colloidal organic material. These materials are the products of water living organisms and organic residues such as waste and water microorganisms.

Besides the increase of colloidal organic matter, colloidal mineral particles were also increased and clay content generally was increased after fish farming. In general it can be concluded that flooding the soil, in some cases increased its cation exchange capacity due to the deposition of clay particles from the flooding water as well as the increase in organic matter content originating from the addition of fertilizers and accumulation of organic compound residues. These results agreed with those obtained by El-Nagdi and Shaker (1997).

Effect of water hyacinth cultivation on ponds on the distribution and levels of micronutrients

The influence of Bahr El-Baqar drain water on the total content of the soil Fe, Mn, Zn, Cu, B, Cd and Pb. As shown in Table (5&6) the continual usage of the untreated sewage water for irrigation has markedly increased the total content of the studied elements compared to the other treatments under cultivation water hyacinth in ponds. These results agree generally with the findings of El-Sikhry (1990) who found that applied sewage effluent increased the content of heavy metals in the soil.

The changes of heavy metals in surface layer (Table 7) were 67.38, 21.68, 28.26, 36.75, 110.75, 59.48 and 59.61% for Fe, Mn, Cu, Zn, B, Cd and Pb, respectively in the control treatment while in 5% water hyacinth cultivation were 19.99, 6.9, 11.42, 11.86, 31.1, 44,09 and 37.53%, and in 20% were 3.6, 0.19, 1.57, 0.89. 7.2, 5.03 and 10.02% far the same metals, respectively.

These results indicated that the cultivation of water hyacinth in ponds decrease the macro/heavy metal in water, then decrease the these metals accumulation in soil layers. These results are in agreement with those obtained by Shaker (1998) who reported that the concentration of heavy metals in soils depend on the concentration of these elements in water and the quantity of irrigation water.

Generally, the increase of water hyacinth cultivation in earthen ponds decrease the heavy metals in water and decrease the heavy metals accumulation in soil layers. While, in the control ponds the heavy metals accumulations in soil layers increased sharply. These results are in agreement with those found by El-Sikhry (1990) who found that the annual increase of heavy metals as a results of using sewage water in irrigation was 506, 25.5, 5.25, 10.5 and 7.99 ppm for Fe, Mn, Zn, Cu and Pb, respectively.

It may be concluded that there is a sharp increase of trace elements in the soil due to irrigation by this sewage water. But a gradual increase in other treatments with cultivation water hyacinth. The aquatic plant cultivation in ponds highly reduces the heavy metal concentration in this water, and the metals accumulate in soil.

Effect of water hyacinth cultivation on water quality

The collected data about water quality parameters during the study are summarized in table (8), the average water temperature was 8.5 °C for all treatments during the study. Generally, water temperature did not differ significantly between all treatments during the study.

The average concentration of dissolved oxygen DO during the experiment were 6.75, 5.78, 4.34, 3.33 and 2.42 mg/L for control, 5, 10, 15 and 20% water hyacinth cultivation in ponds, respectively. DO concentrations gradually decrease with the increase of water hyacinth cultivation in ponds. and differed significantly between all treatments during the experiment. These results are in agreement with those found by Corpron and Armstrong (1983).

On the other hand, similar trends were observed in pH, nitrogen compounds NH_4, NH_3, NO_3 and TN mg/L. Nitrogen compound decrease in ponds water may be due to their removed by physical, chemical or biological means, but the most frequent application has been biological filtration systems utilizing nitrofying bacteria. These results are in agreement with those obtained by Corpon and Armstrong (1983), found that the usefulness and practicality of including the aquatic plant *Elodea densa* as a component of the biological filtration system to attenuate inorganic nitrogen levels in *Macrobrachium rosenbergii* culture tanks.

Floating and submerged aquatic plants removed 12.0-15.8% of the nitrogen compound added as feed during the study. Rai *et al.* (1998), found that the aquatic plant removed about 15-25% of nitrogen compound from water and soil.

As presented in Table (8) results show that E.C. and salinity were slightly decreased with the increase of aquatic plant cultivation in ponds. Total alkalinity and total hardness did not differ significantly among control, 5 and 10%, whereas they decrease significantly ($P<0.05$) in 15 and 20%.

Phosphorus is a key nutrient in ponds. Total phosphorus and orthophosphate decreased with each increase in aquatic plant cultivation in ponds. These results may be due to the uptake of phosphorus by water hyacinth.

Results presented in Table (9) show that heavy metal (mg/L) concentration in water significantly decrease ($P<0.01$) with the increase of water hyacinth cultivation in ponds. The average concentrations of iron (Fe) were 4.43, 3.27, 1.92, 0.95 and 0.75 mg/L in control, 5, 10, 15 and 20% respectively. Also, similar trend was observed in manganese Mn, the average concentration of decreased significantly with the increase of water hyacinth cultivation in ponds.

Results of Table 9 data show that the average concentration of heavy metals in water ponds gradually decreased with each increase in water hyacinth cultivation in ponds. The average concentration of Cu were 0.568, 0.45, 0.242, 0.122 and 0.093 mg/L in control, 5, 10, 15 and 20%, respectively. Also, Zn concentrations were 0.648, 0.482, 0.328, 0.135 and 0.095 mg/L for the same treatments, respectively. Also, similar trends were observed in B, Cd and Pb during the experiment.

In general, data of heavy metals concentration in water were suitable for fish well being in treatments 10, 15 and 20%. In addition, aquatic plant "water hyacinth" plays a major role in the biogeochemical cycling of microelement.

From the above mentioned discussion, it could be concluded that the average concentration of the studied elements were in the safe level for fish and aquatic life in treatments 10, 15 and 20% water hyacinth cultivation in ponds.

These results are similar to those of Rai *et al.* (1998) who found that the duckweed *Lemna minor* removed about 75-100% of Cu, 50-90 of Fe, 35-55% of Pb and 60-85 of Mn.

Based on the above findings it may be concluded that heavy metal concentrations in water, soil and fish reduced significantly by cultivation the ponds by aquatic plant such as water hyacinth 10, 15 and 20% from the surface area. Finally, it could be concluded that the best treatments were 10 and 15% water hyacinth in ponds. However, more studies are needed to reveal and evaluate the risk of viral pathogens for fish growers, processors and consumers.

Table 1. Soil particle size distribution for different treatments before cultivation.

Treatments	Depth/cm	Sand %	Silt %	Clay %	Texture
Control	0 – 20	38.0	25.1	36.9	Silty clay loam
	20-40	43.0	28.4	28.3	Sandy clay loam
5%	0 – 20	38.5	25.6	35.9	Silty clay loam
	20-40	42.9	27.8	29.3	Sandy clay loam
10%	0 – 20	39.1	25.4	35.5	Silty clay loam
	20-40	43.0	28.1	28.9	Sandy clay loam
15%	0 – 20	39.6	25.6	34.8	Silty clay loam
	20-40	44.7	27.9	27.4	Sandy clay loam
20%	0 – 20	38.9	25.8	35.3	Silty clay loam
	20-40	44.1	26.9	29.0	Sandy clay loam

Table 2. Soil particle size distribution for different treatments after cultivation.

Treatments	Depth/cm	Sand %	Silt %	Clay %	Texture
Control	0 – 20	31.4	30.1	38.5	Clay loam
	20-40	41.1	29.0	29.9	Sandy clay loam
5%	0 – 20	32.4	30.7	36.9	Clay loam
	20-40	41.3	27.4	31.3	Sandy clay loam
10%	0 – 20	33.7	30.4	35.9	Clay loam
	20-40	41.6	29.2	29.2	Sandy clay loam
15%	0 – 20	33.9	30.1	36.0	Clay loam
	20-40	42.9	29.4	27.7	Sandy clay loam
20%	0 – 20	33.7	30.2	36.1	Clay loam
	20-40	41.9	29.1	29.0	Sandy clay loam

Table 3. Soil chemical properties for different treatments under investigation before cultivation.

Treatments	Depth cm	PH 1:2.5	E.C mmhos /cm	O.M %	Cations and anions meq/l 1:5								CEC meq/100g soil	SAR	T.N ppm	Available macro. ppm		
					Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4				N	P	K
Control	0 – 20	8.42	4.72	1.86	19.72	18.56	32.78	3.24	6.12	20.56	38.16	9.46	23.42	7.5	190.6	21.8	20.22	96.0
	20-40	8.24	4.7	1.58	18.52	17.04	26.12	2.06	1.14	18.12	36.4	8.08	19.26	6.19	166.4	20.1	16.14	70.0
5%	0 – 20	8.38	4.66	1.66	20.18	18.42	32.14	3.56	5.26	21.72	36.36	10.96	21.2	7.32	170.4	20.56	18.98	88.0
	20-40	8.24	4.72	1.4	19.22	16.92	27.72	2.42	1.22	18.66	34.8	11.6	20.1	6.52	144.8	17.48	16.9	70.0
10%	0 – 20	8.4	4.82	1.7	21.88	15.98	35.16	3.62	5.94	22.74	37.72	10.24	21.76	8.08	176.2	21.42	20.12	90.0
	20-40	8.2	4.78	1.6	19.14	15.02	32.32	2.18	1.12	21.52	35.78	10.24	19.42	7.83	165.2	20.4	18.6	72.0
15%	0 – 20	8.36	4.76	1.72	19.52	19.92	36.56	3.72	6.06	25.62	38.12	9.92	22.18	8.23	180.2	21.96	20.72	90.0
	20-40	8.26	4.8	1.56	18.66	18.08	30.1	1.96	1.36	22.96	34.72	9.76	20.14	7.02	160.8	20.12	14.88	72.0
20%	0 – 20	8.32	4.82	1.8	19.72	18.42	35.5	3.66	6.02	25.9	37.56	7.82	22.84	8.12	186.6	21.48	20.56	92.0
	20-40	8.22	4.76	1.62	19.12	18.3	30.1	2.12	1.56	23.72	35.84	8.52	20.3	6.95	170.8	20.66	17.36	74.0

Table 4. Soil chemical properties for different treatments under investigation after cultivation.

Treatments	Depth cm	pH 1:2.5	E.C mmhos /Cm	O.M %	Cations and anions meq/l 1:5								CEC meq/100g soil	SAR	T.N ppm	Available macro. ppm		
					Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4				N	P	K
Control	0 – 20	8.02	5.12	4.96	31.56	27.98	56.72	4.58	-	32.92	68.69	19.23	26.72	10.39	398.8	26.2	30.36	112.0
	20-40	7.92	5.16	3.06	27.72	24.92	46.02	2.76	-	28.36	59.92	13.14	22.14	8.97	256.4	24.4	22.28	88.0
5%	0 – 20	7.92	5.02	3.42	30.26	26.22	53.52	4.56	-	32.62	66.66	15.28	26.02	10.08	280.8	25.5	26.24	101.0
	20-40	7.82	5.0	2.46	27.54	23.14	45.72	2.52	-	27.72	56.92	14.28	21.42	9.09	204.1	24.06	21.4	82.0
10%	0 – 20	7.8	5.12	2.8	30.32	22.9	55.12	4.24	-	32.14	64.88	15.56	25.52	10.68	264.2	26.02	27.1	100.0
	20-40	7.62	5.08	2.0	26.54	21.1	48.92	2.2	-	29.76	55.96	13.04	22.12	10.02	196.4	21.02	24.7	80.0
15%	0 – 20	7.7	5.02	2.28	27.7	25.18	54.72	4.12	-	34.18	64.6	12.94	24.18	10.65	228.8	23.72	25.26	98.0
	20-40	7.5	5.06	1.66	24.88	23.1	44.14	1.82	-	30.76	53.26	9.92	22.02	9.01	280.1	22.9	18.12	78.0
20%	0 – 20	7.46	5.02	2.0	25.92	23.62	51.72	3.92	-	33.92	62.72	8.54	24.04	10.39	218.1	23.76	22.78	95.0
	20-40	7.3	4.98	1.68	24.66	21.78	44.32	1.98	-	30.68	54.24	7.82	21.78	9.19	182.1	23.12	18.66	76.0

Table 5. Some trace elements (ppm) of the soil ponds before experiment.

Treatments	Depth cm	Fe	Mn	Cu	Zn	B	Cd	Pb
Control	0 – 20	39.98±2.41	5.72±0.22	10.12±0.24	4.38±0.09	14.88±1.02	6.12±0.06	8.12±0.06
	20-40	42.76±2.65	5.96±0.14	10.92±0.28	4.56±0.11	16.96±0.92	6.38±0.05	8.76±0.07
5%	0 – 20	44.16±1.36	4.92±0.32	9.98±0.32	4.72±0.09	15.24±1.14	6.26±0.09	7.78±0.09
	20-40	48.78±2.55	5.12±0.12	10.36±0.22	4.9±0.14	17.36±0.78	6.22±0.06	8.06±0.09
10%	0 – 20	40.7±3.02	4.76±0.14	10.08±0.42	4.76±0.16	14.98±0.76	6.44±0.06	7.88±0.05
	20-40	45.24±1.24	4.98±0.12	10.36±0.26	4.98±0.06	17.18±1.04	6.6±0.05	8.42±0.05
15%	0 – 20	39.92±1.06	4.88±0.1	10.18±0.32	4.92±0.09	15.22±0.92	6.1±0.09	7.98±0.1
	20-40	43.86±2.4	5.18±0.2	10.38±0.38	5.26±0.06	16.98±1.12	6.2±0.1	8.46±0.05
20%	0 – 20	40.04±1.56	5.14±0.12	10.16±0.42	4.48±0.12	14.44±1.22	6.36±0.03	7.98±0.06
	20-40	42.42±2.58	5.52±0.21	10.48±0.26	4.88±0.09	15.92±1.14	6.52±0.06	8.84±0.1

Table 6. Some trace elements (ppm) of the soil ponds after experiment.

Treatments	Depth cm	Fe	Mn	Cu	Zn	B	Cd	Pb
Control	0 – 20	66.92±2.66	6.96±0.22	12.98±0.12	5.99±0.09	31.36±0.96	9.76±0.09	12.96±0.1
	20-40	58.98±1.76	6.58±0.16	11.96±0.38	5.66±0.18	30.06±1.36	8.88±0.12	11.04±0.1
5%	0 – 20	52.99±1.7	5.26±0.14	11.12±0.46	5.28±0.17	19.98±1.11	9.02±0.11	10.7±0.11
	20-40	56.09±1.32	5.32±0.12	11.02±0.4	5.32±0.14	20.92±1.22	8.48±0.09	9.12±0.09
10%	0 – 20	44.77±1.96	4.86±0.14	10.98±0.38	5.02±0.12	17.86±0.98	8.52±0.1	10.08±0.06
	20-40	47.9±2.72	5.02±0.16	10.56±0.3	5.02±0.09	19.06±1.08	7.14±0.06	9.04±0.12
15%	0 – 20	41.9±1.32	4.9±0.12	10.48±0.28	5.12±0.12	16.72±1.02	7.04±0.05	9.32±0.1
	20-40	46.05±2.42	5.20±0.14	10.58±0.46	5.4±0.11	18.02±1.22	6.46±0.12	9.06±0.1
20%	0 – 20	41.5±1.26	5.15±0.1	10.32±0.44	4.52±0.16	15.48±1.16	6.68±0.06	8.78±0.06
	20-40	43.69±1.22	5.52±0.24	10.52±0.32	4.88±0.14	15.98±0.92	4.68±0.06	9.12±0.09

Table 7. Changes of some trace elements in soil surface and subsurface after the experiment as %.

Treatments	Depth Cm	Control	5%	10%	15%	20%
Fe	0-20	67.38	19.99	10.00	4.96	3.60
	20-40	37.93	14.99	5.93	4.99	2.99
Mn	0-20	21.68	69.00	2.10	0.40	0.19
	20-40	10.40	3.90	0.80	0.39	0.00
Cu	0-20	28.26	11.42	8.93	2.95	1.57
	20-40	9.50	6.37	1.93	1.93	0.38
Zn	0-20	36.75	11.86	5.46	4.07	0.89
	20-40	24.12	8.57	4.42	2.66	0.00
B	0-20	110.75	31.10	19.22	9.86	7.20
	20-40	77.24	20.51	10.94	6.12	0.38
Cd	0-20	59.48	44.09	32.29	15.40	5.03
	20-40	39.18	36.33	8.18	4.19	2.45
Pb	0-20	59.61	37.53	27.92	16.79	10.02
	20-40	26.02	13.15	7.36	7.09	3.17

Table 8. The average of some physico-chemical characteristics of water samples collected from sewage wastewater fish ponds during the experimental pariod.

Treatments	Control	5%	10%	15%	20%
Temp. °C	28.82±2.3 a	28.65±2.3 a	28.48±1.7 a	28.42±2.2 a	28.27±2.2 a
D.O mg/L	6.75±0.3 a	5.78±0.36 b	4.35±0.4 c	3.33±0.5 d	2.42±0.5 e
S.D Cm	6.33±1.0 e	10.97±1.4 d	16.55±1.7 c	22.92±2.9 b	30.88±3.2 a
pH	9.34±0.2 a	9.13±0.2 ab	8.93±0.15 b	8.7±0.15 b	8.51±0.15 c
NH_4 mg/L	7.38±0.38 a	5.83±0.42 b	3.25±0.52 c	0.99±0.16 d	0.54±0.08 e
NH_3 mg/L	3.71±0.21 a	2.72±0.31 b	1.61±0.32 c	0.75±0.11 d	0.29±0.06 e
NO_3 mg/L	0.42±0.1 a	0.32±0.05 b	0.25±0.03 b	0.18±0.02 c	0.09±0.01 c
T.N mg/L	2.44±0.2 a	2.02±0.12 b	1.71±0.1 c	1.32±0.1 d	0.83±0.07 e
E.C mnohs/Cm	5.67±0.1 a	5.59±0.2 a	5.47±0.1 a	5.38±0.2 ab	5.13±0.1 b
Salinity g/L	2.77±0.1 a	2.71±0.1 a	2.67±0.1 a	2.62±0.0 ab	2.53±0.1 b
T. alk. mg/L	343.4±25.5 a	326.3±34.6 a	321.68±33.2 a	295.88±21.9 b	272.03±14.8 b
T.H mg/L	1265.6±27.9 a	1223.5±33.2 a	1190.2±32.1 a	1120.9±21.7 b	1030.1±14.8 b
T.P mg/L	2.775±0.27 a	2.235±0.21 b	1.9±0.18 c	1.62±0.14 d	1.29±0.11 e
O.P mg/L	1.16±0.1 a	0.88±0.09 b	0.68±0.08 c	0.54±0.4 d	0.39±0.01 e

[a-e]Means with the same letters in the same raw are significantly different ($P > 0.05$) using ANOVA.

Table 9. The average concentration of some trace elements (mg/l) in water samples collected from during the experimental pariod.

Treatments	Control	5%	10%	15%	20%
Fe	4.43±0.126 a	3.27±0.124 b	1.92±0.076 c	0.95±0.072 d	0.78±0.042 d
Mn	0.18±0.032 a	0.14±0.013 a	0.08±0.004 b	0.042±0.004 c	0.032±0.002 c
Cu	0.568±0.092 a	0.45±0.074 b	0.242±0.054 c	0.122±0.033 d	0.093±0.016 d
Zn	0.648±0.075 a	0.482±0.049 ab	0.328±0.047 b	0.135±0.024 c	0.095±0.016 c
B	0.863±0.107 a	0.683±0.075 b	0.393±0.07 c	0.225±0.045 d	0.167±0.024 d
Cd	0.217±0.012 a	0.155±0.014 b	0.095±0.006 c	0.05±0.003 d	0.037±0.017 d
Pb	0.468±0.046 a	0.335±0.03 b	0.205±0.012 c	0.123±0.004 d	0.09±0.001 d

[a-d]Means with the same letters in the same raw are significantly different ($P > 0.05$) using ANOVA.

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أثر زراعة نبات ورد النيل فى الاحواض الارضية على تراكم العناصر الثقيلة فى التربة

ابراهيم محمد شاكر عبد الفتاح

المعمل المركزى لبحوث الأسماك بالعباسه - مركز البحوث الزراعية - وزارة الزراعة - الدقى - جيزة.

أجريت هذه الدراسة فى منطقة شادر عزام-محافظة بور سعيد وذلك بهدف دراسة استخدام نبات ورد النيل كمرشح بيولوجي لمصادر التلوث المختلفة الموجودة فى مياه الصرف الصحي المستخدمة فى الإستزراع السمكى. أجريت هذه الدراسة فى عدد ١٥ حوض ترابى مساحة كل منها ٣٥٠ م٢ وهى تروى من مياه مصرف بحر البقر مباشرة وتم تقسيم هذه الأحواض إلى خمسة معاملات. الأولى كنترول وهى بدون زراعة نبات ورد النيل بها وباقي المعاملات تم زراعة نبات ورد النيل بها بكثافات كانت ٥ ، ١٠ ، ١٥ ، ٢٠ ٪ من مساحة الحوض كما تم زراعة الأحواض بأسماك البلطى النيلى والبوري بنسبة ٥٠ ٪ لكل منهما. وقد لوحظ من النتائج أن استخدام ورد النيل يقلل من العناصر الصغرى الموجودة فى المياه والتربة والأسماك. أيضا لوحظ أنه بزيادة نسبة زراعة نبات ورد النيل بالحوض يزداد معدل الانخفاض فى العناصر الصغرى محل الدراسة فى المياه والتربة والأسماك وأخيرا وجد أن أفضل المعاملات كانت ١٠ ، ١٥ ٪ نسبة زراعة لنبات ورد النيل حيث أن الانخفاض فى العناصر الصغرى كبير والانخفاض فى الإنتاجية السمكية بسيط نوعا.