WASTEWATER REMEDIATION WITH WATER HYACINTH (EICHHORNIA CRASSIPES)

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ABSTRACT

Natural Water hyacinth, *Eichhornia crassipes*, (density 90%) grown on a defined polluted water section (10,000 m^2) was used as a treatment, before the water is pumped through El-tabia Pump Station (TPS) to the sea. The experiment was repeated twice on March and June, 1997. The average removal over the studied period (the first 15 days of each month) was 24% of suspended solids (SS), 17% COD, 29% TDS, 25% total nitrogen (TN) and 24% total phosphorus (TP) for March. Where June average was 28% of SS, 12% COD, 16 % TDS, 24% TN and 14% TP. Removal of mercury, lead, and copper were also determined. Mathematical modeling was made to test the water quality and the optimum number hyacinth sections. It is recommended to increase the hyacinth sections to 10 to render the remediated water suitable for agricultural use. This could amount to 600 million m^3 of remediated water annually, saving 100 million L.E. from the point of view of environmental benefits and human health, overcoming the serious Abu-Quir Bay contamination. Further studies will be needed from the point of view of bacteriology.

Keywords: Wastewater remediation, Natural treatment, Water hyacinth, *Eichchornia crassipes*, Abu-Quir Bay.

INTRODUCTION

Wastewater treatment is a problem that has plagued man ever since he discovered that discharging his wastes into surface waters can lead to many serious environmental problems. In the early 1960s, natural treatment systems have been intensively researched as treatment options for municipal, industrial and mine wastewater. The water hyacinth, *Eichhornia crassipes*, (Mart), Solma, is a tropical species well known for its rapid reproduction and biomass [1,2] and its capability to remove different pollutants from domestic and industrial waste effluents, [3-5].

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The purpose of this stud was to estimate the capability of naturally growing hyacinth in El-Amia drain to remove organic matter (OM), (SS), dissolved solid (DS), dissoleved nitrogen (DN) and dissolved phosphorus (DP), as well as removal of mercury, lead, and copper. The experiment was repeated twice on Mach and June 1997.

MATERIALS AND METHODS

Site Description

El-Amia drain (AD) extends for 30 km through Baheira Governerate ending at eastern district of Alexandria coast, (2.5km-Figure 1). The drain receives a substantial boarder of pollutants from about 38 industrial plants of large, medium and small sizes, as Well as agricultural, and domestic wastes. These represent about 8 major categories of industrial activities; such as food processing, pulp and paper, fertilizers and agrochemicals, detergents, chemical fibers, dyestuffs production, textile spinning and weaving, as well as building materials. The daily average industrial discharge into AD is 30,000 m^3, added to agricultural

wastes to 1.2 to 2.1 million m^3/day. The domestic sewage amounts to 128,000 to 216,000 m^3/day. No sufficient waste treatment is available before discharge to the Mediterranean. Hence, natural treatment was suggested as efficient and cheap remediation of wastewater.

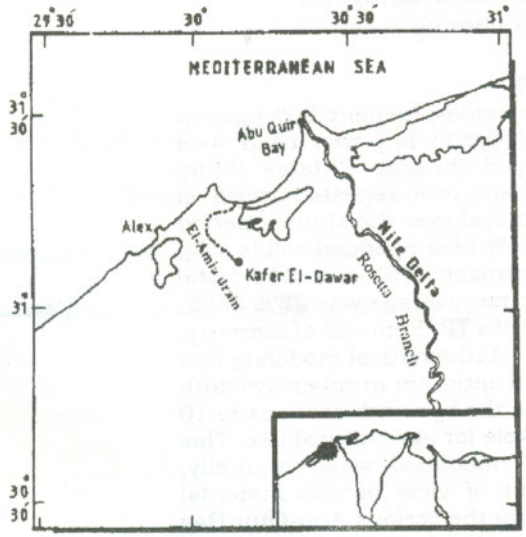

Figure 1 Location of El-Amia Drain

Location: A section of 10,000 m^2 (500 X 20 m) was selected as the study location, near the terminal of the drain, (0.2km) before the TPS settling basin where the water is pumped directly to the coastal sea water via TPS, (2 to 2.6 million m^3/day of wastewater (600 million m^3/yr). The selected location (Figure 1) is naturally covered with hyacinth (85 to 95%)

Collective sampling (2.5 L x 3) was carried out across the drain (two sides and the middle) at 15 cm depth using 2.5 L dark Winshester bottle. Sample portions were mixed thoroughly. Water was sampled daily (first 15 days of March 1997). The experiment was repeated on June 1997. Temperature and pH were measured on spot before being transferred to the Lab. Temperature ranged from 23 to 25°C (March), and 25-29°C (June), while Light intensity range from 1300 to 1900 $\mu E/M^2$/sec. Determination of SS, total dissolved solids (TDS), COD, total organic carbons (TOC), total nitrogen (TN), total phosphorus (TP), phenols , Hg, Cu, and Pb were as performed according to standard methods for examination of water and wastewater, [6]

RESULTS AND DISCUSSION

A wastewater treatment section covered with water hyacinth (*Eichhornia crassipes*) was first tested in Bahia in an attempt to treat sewage from an urban area in Bahia, Brazil. The treated pond was reported to receive a high organic load of 750 kg BOD/ha/day. After a short detention time of as little as 5 days, a removal rate of 90.7% of BOD and 96% of suspended solids was achieved [7]. Likewise, a daily removal of 40% SS, 35% COD and 21% BOD was achieved for paper industry effluent, using water hyacinth pond [5].

Such approach seemed attractive to be extended for running effluents streams. For this end a water stream "El Amia drain" was selected, as to evaluate the efficiency of the method in remediation of this wastewater. Ten parameters were chosen (Tables 1 and 2), for evaluation. The values obtained are expressed as collective grand total (GT, mg/L) of all ten parameters. Comparison between GT values input and output were evaluated the hyacinth efficiency for pollution removal. This mathematical treatment would simply reflect the net efficiency of the treatment, rather than comparing the pre- and post- treatment corresponding values. The average daily site monitoring values for 15 days were 18% and 14% for March and June 1997, respectively; as compared to 75-95% removal reported for pond treatment [5].

The rather lower efficiency of running stream section treatment is apparently due to the decreased detention time of the running waters, as compared to a minimum of 5 days [7].

Table 1 Concentration (mg/L) of studied parameters in input and output effluent, and percentage of removal in water Hyacinth section in March.

Parameter	Input	output	Removal average %
SS	54 ± 30	41 ± 10	24
TDS	350 ± 105	250 ± 75	29
COD	1080 ± 270	900 ± 180	17
TOC	2280 ± 580	1900 ± 460	17
TN	24 ± 10	18 ± 7	25
TP	17 ± 7	13 ± 4	24
Hg	0.2 ± 0.1	0.1 ± 0.05	50
Cu	1.8 ± 1.0	1.1 ± 0.5	40
Pb	0.8 ± 0.2	0.5 ± 0.2	38
Phenols	9.9 ± 4.3	6.5 ± 2.8	35
GT	3817.7	3130.2	18

Table 2 Concentration (mg/L) of studied parameters in input and output effluent, and percentage of removal in water Hyacinth section in June.

Parameter	Input	Output	Removal average %
SS	86 ± 44	75 ± 25	13
TDS	510 ± 210	430 ± 160	16
COD	1590 ± 318	1410 ± 222	12
TOC	3150 ± 1517	2700 ± 410	15
TN	30 ± 12	23 ± 7	24
TP	22 ± 9	19 ± 5	14
Hg	0.01 ±0.004	0.005 ± 0.001	50
Cu	1.2 ± 0.4	0.7 ± 0.2	42
Pb	0.6 ± 0.2	0.4 ± 15	33
Phenols	12.8 ± 5.1	10.5 ± 4.3	18
GT	5402.61	4668.605	14

For the heavy elements (Hg, Cu, and Pb), The average removal percentage were 50, 40 and 38% for March and 50, 42 and 33% for June, respectively, (Tables 1 and 2). Although mercury removal can be attributed to evaporation at ambient temperature as well as adsorption on hyacinth roots.

The removal of SS ranged from 24 to 28% which can be attributed to precipitation due to decrease in water flow and also to the water root filtration. While these results agree well with those reported by De-Casabianca [5]. They are different from those given by Santos *et al.* [7] for closed pond treatment over a 5 days period.

Likewise, the efficiency of COD removal by water hyacinth ranged from 17 to 12 % for March and June respectively, while the removal of TOC ranged from 15 to 17%. Notable variation in TDS removal by water hyacinth 26 - 16% for March and June, respectively. This observation can be attributed to ambient temperature and rate of flow. TN was removed with similar percentage (24%) for March and June. The removal of Tp was 24 for March and decreased to 14% for June. While, phenols removal decreased from 35% (March) to 18% (June), that could be attributed to the input concentration. Further studies will be needed from the point of view of bacteriology.

Based on the above results an empirical model was designed. Mathematical computer modeling was made to evaluate the water quality according to an optimum number of hyacinth sections required for such levels of remediation. Accordingly, ten hyacinth section are recommended for water remediation as to suit the local agriculture standards of water quality.

ECONOMIC VISIBILITY

1. The system is poor for the removal of nutrients, due to low retention time and water flow. Hence, section replication (3 km apart) will increase the retention time and contact duration between Hyacinth and water.
2. From an ecological point of view, biological control of mosquitoes in hyacinth areas should be stimulated, instead of chemical control, hence this control, as much as possible, of human interference.
3. Recycling of the above mentioned annual volume of 600 million m^3 waste water, (which discharged by TPS) in agriculture, would save up to 100 million L.E .
4. This type of remidiation is very beneficial and can be applied with liquid wastewater in long open channel.

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تنقية المياه الملوثة باستخدام نبات ورد النيل

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ملخص البحث

يتواجد نبات ورد النيل بصورة طبيعية ومكثفة فى المصارف. ويعتبر مصرف العامية (تحت الدراسة) من المصارف المتميزة، حيث أنه يستقبل مياه ملوثة من مصادر متعددة، فمنها مصادر زراعية (٤٢ ألف فدان) بكميات تصل ١,٢ إلى ٢,١ مليون متر مكعب يوميا، ومصادر صناعية (أكثر من ٢٠ مصنع) بكميات تصل ٣٠ ألف متر مكعب يوميا، بينما يتراوح الصرف الصحـــي الـــتى تستقبله مياه مصرف العامية من ١٢٨ إلى ٢١٦ ألف متر مكعب يوميا. وتقوم محطة طلمبات الطابية برفع حوالي ٢,١ إلى ٢,٧ مليون متر مكعب يوميا من مياه المصرف لتلقى بها فى خليج أبو قير.

وكان الهدف من هذه الدراسة هو استخدام ورد النيل كوسيلة طبيعية لتنقية وتحسين حالة مياه المصرف. وتم تحديد قطاع يمثـــل ١٠,٠٠٠ متر مربع من ورد النيل بكثافة ٩٠%، خلال شهرى مارس ويوليو عام ٩٧ (مدة الدراسة فى كل شهر ١٥ يوم) وتم قياس عدد من معايير التلوث قبل وبعد قطاع ورد النيل. وكانت نتائج معدل التنقية كالتالي: ٢٤% للمـــواد العالقـــة، ١٧% الأكسجين الكيميائي المستهلك، ٢٩% من المواد الذائبة الكلية ٢٥% للنتروجين الكلى، ٢٤% للفوسفور الكلـــى فى شـــهر مارس. بينما فى شهر يوليو تراوحت هذه النسب كالتالي: ٢٨% للمواد العالقة، ١٢% الأكســـجين الكيميـــائي المســـتهلك، ١٦% من المواد الذائبة الكلية ٢٤% للنتروجين الكلى، ١٤% للفوسفور الكلى. وبلغ معدل التخلص من العنـــاصر الثقيلـــة تحت الدراسة بحوالي ٤٠%. وللوصول بمياه المصرف لمعايير المياه المستخدمة فى الرى يمكن تكرار قطاع ورد النيل كل ٢,٥ كيلو بطول المصرف، وبذا يمكن توفير حوالي ٦٠٠ مليون متر مكعب مياه صالحة للزراعة سنويا. ويعتبر هذا البحث مـــن البحـــوث البيئية التطبيقية. ويمكن أن تطبق فكرة هذا البحث فى المصارف التى تنقل المخلفات السائلة لمسافات طويلـــة. كمـــا أن وجـــود كثافات نباتية بهذه المساحة تزيد من معدل ترسيب المواد العالقة الكلية.