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PHYTOREMEDIATION OF AGRICULTURAL SEWAGE WATER BAHR HADOUS USING AZOLLA PINNATA

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ABSTRACT: Water is vital for humans and other living things, but water pollution has become a significant issue today. Various anthropogenic agricultural, industrial, and home activities produce multiple organic and inorganic substances dissolved or suspended in water. The goal of wastewater treatment is thus twofold: to reduce water pollution while also maintaining the water supply to demand. In a 15-day controlled laboratory experiment, Azolla pinnata was used to biotreat wastewater collected from Bahr Hadous, Egypt. It was tested on three levels of wastewater and tap water as a control treatment (5, 10, and 20 cm). The current study aimed to evaluate the ability of Azolla to treat wastewater at different depths. The results of the study showed a decrease in pH, electrical conductivity, cations, anions, some heavy metals, nitrate, and phosphorus, with the optimum depth being 10 cm. Furthermore, the effectiveness of Azolla in treating wastewater was evaluated and its use for irrigation purposes.

Key words: Azolla, wastewater, treatment.

INTRODUCTION

Water pollution is a pressing global issue resulting from the release of diverse pollutants into water sources. These contaminants stem from various origins, including industrial operations, agricultural practices, and inadequate waste disposal. Typical pollutants comprise a broad spectrum of substances, including pesticides, heavy metals, textile dyes, inorganic chemicals, and radioactive substances **(Kaur *et al*., 2016).** Water scarcity and contamination are pervasive global challenges, impacting approximately 40% of the world's population. The interplay of climate change, urbanization, intensive agriculture, and unsustainable resource use fuels these pressing issues **(Stringer *et al*., 2021).**

The importance of effective and eco-friendly wastewater treatment cannot be overstated. Aquatic plants like macrophytes offer a promising solution for purifying water with low nutrient levels. However, the release of heavy metals and excess nutrients from industrial and agricultural activities poses a significant threat to water quality, leading to eutrophication. Given the limitations of traditional treatment methods in terms of cost and energy efficiency, developing affordable and sustainable alternatives is critical, particularly for small-scale applications **(Taghilou *et al*. 2023).**

The development of innovative treatment methods is critical to enhance efficiency and reduce costs. Phytoremediation, a plant-based bioremediation process, provides an environmentally friendly approach to removing pollutants from water and soil, leveraging the natural capabilities of plants and their associated microorganisms to restore ecosystems.

Macrophytes have emerged as a promising solution for wastewater treatment, offering a range of benefits including simplicity, high biosorption potential, and low operational costs. The use of biosorption techniques, which leverage the natural capabilities of macrophytes,

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provides a cost-effective and efficient approach to wastewater treatment. Aquatic macrophytes, such as Azolla, have shown remarkable potential in removing both organic and inorganic pollutants, making them an attractive option for improving water quality **(Kochi *et al*., 2020; Nedjimi, 2021; Jayasundara, 2022) .**

Researchers investigated the ability of Azolla to remove fluoride, ammonium, bisphenol A, dye, nitrogen, phosphorus, zinc ions and heavy metals (e.g., Pb, Cd, Ni and Cu) from wastewater. Using of Azolla can be a suitable and cost-effective option for phytoremediation of polluted water **(Prabakaran *et al*., 2022)**. In phytoremediation with Azolla, the excess biomass, which may contain high pollutant concentrations, must be properly disposed of. Due to the risk of bioaccumulation, using Azolla grown in polluted water as feed is concerning **(Rai, 2020).** Instead, producing bioenergy from Azolla biomass grown in wastewater with toxic metals or harmful organic compounds is a safer option **(Thakur & Kumar, 2021).** Most research has been conducted on a laboratory scale, and thus, real-world studies are recommended to confirm effectiveness under practical conditions **(Pandey *et al*., 2019)**.

Azolla can also be transformed into a nutrient-rich organic fertilizer, rendering it an eco-friendly approach for pollutant removal **(Bhuvaneshwari *et al*., 2022).** Phytoremediation with Azolla is suggested as an advanced treatment following conventional wastewater methods due to its efficiency, low cost, and environmental benefits **(Choudhury & Kennedy, 2021)**. However, further research is needed to evaluate Azolla's effectiveness in real water bodies and to enhance its potential for removing emerging pollutants. Additionally, Azolla's rapid growth rate and high protein and fatty acid content make it a valuable feed, but only when grown in uncontaminated conditions **(Sholeh *et al*., 2019)**. The objective of this study was to investigate the effectiveness of Azolla pinnata in treating selected agricultural wastewater by evaluating its efficiency in removing heavy metals and other chemical parameters after the phytoremediation process. Furthermore, the study examined the biomass production of Azolla pinnata post-treatment to assess the plant's suitability and the overall efficacy of the phytoremediation process.

MATERIALS AND METHODS

Materials

Samples of agriculture sewage water were collected from Bahr Hadous agricultural sewage station, Egypt.

Azolla pinnata strain was obtained from Microbiology, Dep. Soils and Water Environment Research Institute (SWERI), Agric. Research Center, Giza, Egypt.

Experimental Design

Samples of agriculture sewage water were collected from Bahr Hadous agricultural swage station, Egypt. Samples were analyzed at laboratory of Microbiology Department, Soils waters and Environmental Institute, Agriculture Research Center (ARC), Giza, Egypt. These samples were exposed to chemical characterization. Azolla pinnata was transferred to plastic pots (32 cm X 15 cm) and tested on three levels of wastewater (5, 10and 20 cm) and tap water as control treatment. One gram of Azolla was injected. After 15 days, Azolla biomass was collected, weighed, and dried at 60°C in an oven until constant weights.

Chemical analysis for parameters and elements

Chemical analysis of sewage wastewater, PH, electrical conductivity (EC), anions like carbonate (CO3-2), bicarbonate (HCO3-), chloride (Cl-), sulphate (SO4-2), cations such as calcium (Ca+2), magnesium (Mg+2), sodium (Na+), potassium (K+), salts like nitrate-nitrogen (NO3-N), ammonia-nitrogen (NH4-N), and some elements as copper (Cu), ferric (Fe) ,manganese (Mn) and zinc (Zn). , Copper and lead as heavy metals were analyzed according to Standard methods described by APHA (1995) before and after inoculation of Azolla pinnata.

Analysis of chlorophyll content

Algal biomass was collected by centrifugation. Chlorophyll was extracted with ethanol and extinction at 649, 665, and 750 nm was determined. Chlorophyll content (Chl, mg/mL) was calculated using the equation **(Rai *et al*. 2006):**

$$Chl = 6.1(E665-E750)+20.04(E649-E750)K$$

where E is extinction at the corresponding wavelength, K is the dilution factor, and 6.1 and 20.04 are extinction coefficients.

Data analysis

Statistical analysis was performed on the data obtained using tools such as Statistical Package for Social Scientists, SPSS (version 20) and Microsoft Excel to carry out Duncan multiple regression test (DMRT), least square difference (LSD) and analysis of variance ANOVA at 95% confidence interval ($P < 0.05$).

RESULTS AND DISCUSSION

Analysis of sewage water before Azolla treatment. The data in Table 1 showed that the analysis of sewage water collected from Bahr Hadous and compared with the data obtained after Azolla treatment

Azolla Growth Analysis

Bioremediation and biodegradation are potential methods for decontaminating contaminated areas by leveraging plant catabolic capabilities. Results of this study demonstrated that *Azolla pinnata* was found to be very effective in reducing sewage water contaminations. *A. pinnata* adapted to wastewater, resulting in normal growth rates, biomass and chlorophyll content throughout the experiment. Biomass dry, wet weight and chlorophyll content were deduced from the data in Table 2 at 5, 10 and 20 cm depth. The lowest dry and wet weight at 10 cm of experiment was 1.6817 ± 0.29^{A} gL^{-1} and $12.9465\pm1.97^{BC}gL^{-1}$ recorded at Bahr Hadous compared with tap water (1.7530 ± 0.150^{A} $gL^{-1}$and 22.2582 ± 0.755^{A} gL^{-1}), respectively. The same results recorded also at the two other depths, then dry and wet weight decreased in all treatments due to the accumulation of some contamin wants. The statistical analysis result showed that there is a insignificant difference ($p<0.05$) among the different water sources in dry weight while, there is highly significant difference ($p<0.05$) among the different water sources in wet weight. The chlorophyll A and chlorophyll B contents increased with treatment in Bahr Hadous at 5 and 10 cm depths, reaching their peak at 5 cm (0.361 ± 0.13^{A} $mgg^{-1}$and 0.257 ± 0.12^{A} mgg^{-1}) compared with tape water (0.281 ± 0.086^{A} mgg^{-1} and 0.223 ± 0.058^{A} mgg^{-1}) respectively. Meanwhile, at 20 cm, both chlorophyll A and B concentrations having the lower chlorophyll contents than tape water experiment. The carotene C content increased with treatment in Bahr Hadous at 5 and 10 cm depths, reaching their peak at 5 cm (0.567 ± 0.19^{A} mgg^{-1}) compared with tape water (0.441 ± 0.08^{A} mgg^{-1}). While, at 20 cm, carotene content having the lower value than tap water treatment. The statistical analysis result showed that there is insignificant difference ($p < 0.05$) among the different water sources in chlorophyll A, B and carotene. The laboratory studies showed that *Azolla* could double its biomass in 3.5 days and grow in a nitrogen-free solution since it does not need a nitrogen nutrient medium for its biomass growing **(Golzary *et al.*, 2018)**. *Azolla* can grow very quickly, and thus cause severe problems mainly in tropical and subtropical regions **(Sadeghi *et al.*, 2013).**

Changes in NPK content in *Azolla* raised in tap water and Bahr Hadous

Plants' primary nutrients are nitrogen, and phosphorus. *Azolla* absorbs nitrogen as nitrate and ammonia, phosphorus as phosphate, and potassium as K+ ions. *Azolla* inoculation in sewage wastewater considerably lowered nitrogen and phosphorus levels. The concentrations of nitrogen and phosphorus in Bahr Hadous were increased to 35 ± 2.88^{B} mgL^{-1}, 0.28 ± 0.04^{A} mgL^{-1} at 5cm respectively (Table 3). While potassium concentration was decreased to 0.4 ± 0.17^{A} mgL^{-1} at 10cm compared with $0.6\pm0.208^{A}mgL^{-1}$ in tap water. The statistical analysis result cleared that there is highly significant concentrations of N, while is a insignificant concentrations of P and K between Bahr Hadous sewage water and tap water at the three levels Table 3. Nitrogen and Phosphorous are the primary nutrients in wastewater and cause eutrophication. The statistical analysis result showed that there is highly significant difference ($p < 0.05$) among the different water sources in nitrogen. The statistical analysis result showed that there is a insignificant difference ($p < 0.05$) among the different water sources in phosphorus and potassium. *Azolla* can absorb and accumulate nitrogen and phosphorus from wastewater. **(Golzary *et al.*, 2018; Soman and Arora, 2018)**.

Table 1. Sewage water analysis before Azolla treatment

pH	EC (dSm^{-1})	Ca^{+2} ($meqL^{-1}$)	Mg^{+2} ($meqL^{-1}$)	Na^{+1} ($meqL^{-1}$)	K^{+1} ($meqL^{-1}$)	Hco_3^- ($meqL^{-1}$)	Cl^{-1} ($meqL^{-1}$)	$So4^{-2}$ ($meqL^{-1}$)	NH4-N ($meqL^{-1}$)	NO3-N($\mu g^{-1}L$)	Po4($\mu g^{-1}L$)	Mn($\mu g^{-1}L$)	CU (μg^1L)	B (μg^1L)	Fe (μg^1L)	Zn (μg^1L)
7.5	2.63	6.97	5.24	12.9	0.54	3.21	14.75	7.7	4.6	5.2	3.58	0.22	0.119	0.25	1.64	0.25

Table 2. Biomass dry weight, wet weight, chlorophyll A, chlorophyll B and carotene C in Azolla culture

Parameters	. Tap water			Bahr Hadous			F valuo
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
Dry weight (gL^{-1})	1.5592 ± 0.405^{A}	1.7530 ± 0.150^{A}	1.6638 ± 0.132^{A}	1.6211 ± 0.32^{A}	1.6817 ± 0.29^{A}	1.6701 ± 0.295^{A}	0.04^{NS}
wet weight (gL^{-1})	9.3717 ± 1.022^{CD}	22.2582 ± 0.755^{A}	14.6717 ± 1.74^{B}	10.3328 ± 0.52^{BCD}	12.9465 ± 1.97^{BC}	7.7011 ± 1.57^{D}	7.58^{**}
Chlorophyll A	0.281 ± 0.086^{A}	0.214 ± 0.093^{A}	0.273 ± 0.073^{A}	0.361 ± 0.13^{A}	0.261 ± 0.047^{A}	0.354 ± 0.038^{A}	0.04^{NS}
(mgg^{-1}) B	0.223 ± 0.058^{A}	0.149 ± 0.032^{A}	0.181 ± 0.012^{A}	0.257 ± 0.12^{A}	0.178 ± 0.06^{A}	0.255 ± 0.045^{A}	0.09^{NS}
Carotene C (mgg^{-1})	0.441 ± 0.08^{A}	0.316 ± 0.11^{A}	0.417 ± 0.057^{A}	0.567 ± 0.19^{A}	0.384 ± 0.17^{A}	0.528 ± 0.14^{A}	0.03^{NS}

Values are means of triplicate reading and standard error (± SE). Different superscripts in the same row indicate significant differences (P <0.05)

Table 3. Changes in NPK content in Azolla raised in tap water and Bahr Hadous

Parameters	. Tap water			Bahr Hadous			F value
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
N(mgL^{-1})	35 ± 4.04^{B}	28 ± 3.21^{B}	56 ± 5.68^{A}	35 ± 2.88^{B}	49 ± 2.08^{A}	28 ± 1.73^{B}	21.58^{**}
P(mgL^{-1})	0.14 ± 0.05^{B}	0.24 ± 0.037^{AB}	0.14 ± 0.05^{B}	0.28 ± 0.04^{A}	0.26 ± 0.047^{AB}	0.26 ± 0.05^{AB}	1.23^{NS}
K(mgL^{-1})	0.3 ± 0.07^{A}	0.6 ± 0.208^{A}	0.6 ± 0.1^{A}	0.3 ± 0.11^{A}	0.4 ± 0.17^{A}	0.2 ± 0.1^{A}	0.90^{NS}

Values are means of triplicate reading and standard error (± SE). Different superscripts in the same row indicate significant differences (P <0.05)

Sewage Water Analysis

pH value, EC, cations and anions

Contents of macronutrients in wheat straw In this study, the initial pH, EC, Ca+2 , Mg+2, Cl- and So4-2 of sewage water were 7.5, 2.63 dSm-1, 6.97 meqL-1, 5.24 meqL-1, 14.75 meqL-1 and 7.7 meqL-1, respectively. AT 5, 10 and 20cm after phytoremediation treatment, the lowest value of pH, EC, Ca+2, Mg+2, Cl- and SO4-2 were 6.38±0.367A, 1.32±0.430AB dSm-1, 2.20±0.550B meqL-1, 1.35±0.624B meqL-1, 9.40±1.834A meqL-1and 2.64±0.940BC meqL-1 at 5cm of Bahr Hadous sewage water compared with tap water. Table 4. The statistical analysis result showed that there is a insignificant difference ($p < 0.05$) among the different water sources in pH, EC , Cl-and So4-2 while, there is highly significant difference ($p < 0.05$) among the different water sources in Ca+2 and Mg+2.The results were similar to the work of **(Kiziloglu *et al*. 2009; Temilola *et al*. 2014; Agbaire *et al*. 2015; Musa *et al*. 2020). Akinbile *et al*. (2015)** reported an increase in the performance of A. pinnata in reducing EC and pH.

Removal of Heavy Metals from Sewage Water.

By analyzing the sewage water in Bahr Hadous treated with *Azolla*, five heavy metals-Cu, B, Fe, Zn and Mn concentrations were recorded 0.01 ± 0.001^{B} mgL^{-1}, 0.10 ± 0.005^{AB} mgL^{-1}, 0.01 ± 0.005^{C} mgL^{-1} , 0.01 ± 0.002^{B} mgL^{-1} and 0.04 ± 0.0115^{CD} mgL^{-1}, respectively at 10 cm. *Azolla* is promising species for the remediation of metal-contaminated water. Thus, their ability to extract Cu, B, Fe, Zn and Mn ions from contaminated sewage water was studied. The presence of *Azolla* in Bahr Hadous sewage water led to decrease all heavy metals at 5 cm, Cu decreased by 91.5%,91.5% and 91.5%, B decreased by48%, 60% and 24% Fe decreased by 98.7% , 99.3% and 88.4%, Zn by 88%,96% and 80% while Mn by 63.6% , 81.8%and 36% **.The statistical analysis clearly showed** high significant concentrations of Cu, Fe and Mn while is a significant concentrations of B and insignificant concentrations of Zn between Bahr Hadous sewage water and tap water at the three levels (Table 5).These results are in agreement with those of **(Divya *et al*. 2012 and Nuzhat *et al.* 2015)** who revealed the role of free floating macrophyte (*A. pinnata*) in phytoremediation technology has an excellent performance in removing huge amount of heavy metals in 10 days of the experimentation period. **Jain *et al.* (1989)** found that *A. pinnata* removed the heavy metals iron and copper from polluted water.

Nitrogen and Phosphorous

The result of Table 5 illustrate that *Azolla* can absorb and accumulate nitrogen (NH4-N and NO3-N) and phosphorous. In this work, the initial NH_4-N, NO_3-N and PO_4 of Bahr Hadous sewage water were 4.6 mgL^{-1}, 5.2 mgL^{-1} and 3.58 mgL^{-1}, respectively. After phytoremediation treatment, the lowest value of NH_4, NO_3 and PO_4 were1.4 ± 0.173^{B} mgL^{-1}, 1.4 ± 0.305^{B} mgL^{-1} and 0.01 ± 0.002^{B} mgL^{-1} of Bahr Hadous sewage water compared with tap water. The statistical analysis result clearly showed high significant concentrations of PO_4, while is a significant concentrations of NO_3-N and insignificant concentrations of NH_4-N between Bahr Hadous sewage water and tap water at the three levels Table 5.These result are in agreement with those publications **(Golzary *et al*., 2018; Soman and Arora, 2018**) have studied the characteristics of Azolla.

CONCLUSION

Plants can take up heavy metals by their roots, or even by stems and leaves, and accumulate them in organs, the accumulation depends on the specific metal element and plant species, and the environmental condition. Therefore,plant systems are used to remove heavy metals from sewage water and provide a good performance. From the above results, it has been concluded that the *Azolla pinnata* is a potential plant for accumulation of heavy metals from contaminated Bahr Hadous waste water. During the experimentation this free floating saprophyte has successfully removed the metals, without production of any toxicity. The percentage removal efficiency and bio concentration factor indicates that this plant is potent tool in the abatement of heavy metal pollution in aquatic ecosystems receiving municipal wastewater. In this study, the feasibility of the dual application of *Azolla* was investigated for wastewater treatment and production of *Azolla* mass. This yielded results proposes an attractive, ecofriendly, and cost-effective method for wastewater treatment. Considering all results, we can conclude that using *Azolla* is an effective method for decreasing nitrogen and phosphorus from the effluent of secondary treatment systems. For further results, more studies should be done by focusing on the realer.

Table 4. Changes in Chemical analysis content in Azolla raised in tap water and Bahr Hadous.

Parameters	. Tap water			Bahr Hadous			F valuo
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
pH	6.82 ± 0.088^{A}	6.88±0.965^{A}	7.54±0.637^{A}	6.38±0.367^{A}	7.02±0.591^{A}	6.66±0.302^{A}	0.77^{NS}
EC(dSm^{-1})	1.04±0.332^{AB}	0.55±0.125 ^{B}	0.55±0.076^{B}	1.32±0.430^{AB}	1.69±0.757^{A}	1.77 ±0.415^{A}	1.12^{NS}
Ca^{+2}($meqL^{-1}$)	2.40±0.611^{AB}	2±0.416^{B}	1.77±0.205^{B}	2.20±0.550^{B}	2.40±0.360^{B}	3.55±0.350^{A}	7.65**
Mg^{+2}($meqL^{-1}$)	2.01±0.346^{B}	1.90 ±0.115^{B}	1.37±0.179^{B}	1.35±0.624^{B}	2.24±0.759^{AB}	3.50±0.375^{A}	5.82**
Na^{+1}($meqL^{-1}$)	5.21±1.53^{BC}	1.15±0.485^{C}	1.82±0.327^{C}	9.14±1.031^{AB}	11.48±1.29^{A}	9.66 ±2.74^{A}	2.72^{NS}
K^{+1}($meqL^{-1}$)	0.82±0.105^{A}	0.40 ±0.152^{A}	0.57±0.135^{A}	0.55 ±0.205^{A}	0.76±0.302^{A}	0.99±0.404^{A}	1.74^{NS}
Hco^{-3}($meqL^{-1}$)	2.30±0.608^{A}	2.10±0.458^{A}	2.30±0.435^{A}	1.2±0.472^{A}	1.80±0.624^{A}	3±1.154^{A}	0.98^{NS}
Cl^{-1}($meqL^{-1}$)	7±1.154^{AB}	2.59±0.906^{B}	2.37±1.408^{B}	9.40±1.834^{A}	12±2.645^{A}	10 ±2.645^{A}	1.90^{NS}
$So4^{-2}$ ($meqL^{-1}$)	1.14±0.126^{CD}	0.76 ±0.274^{D}	0.86 ±0.260^{D}	2.64±0.940^{BC}	3.08±0.942^{AB}	4.70±1.113^{A}	2.37^{NS}

Values are means of triplicate reading and standard error (± SE). Different superscripts in the same row indicate significant differences (P <0.05)

Table 5. Changes in heavy metals content in Azolla raised in tap water and Bahr Hadous

Parameters	. Tap water			Bahr Hadous			F value
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
Cu(mgL^{-1})	0.01±0.001^{B}	0.01±0.002^{B}	0.06±0.015^{A}	0.01±0.005^{B}	0.01±0.001^{B}	0.01±0.004^{B}	7.43**
B(mgL^{-1})	0.09±0.005^{BC}	0.04±0.01 ^{C}	0.06±0.015 ^{C}	0.13±0.029^{BC}	0.10±0.005^{AB}	0.19± 0.023^{A}	5.15*
Fe(mgL^{-1})	0.03±0.01^{BC}	0.03 ±0.01^{BC}	0.05±0.015 ^{B}	0.02±0.01^{BC}	0.01±0.005^{C}	0.19±0.030^{A}	25.27**
Zn(mgL^{-1})	0.01±0.001^{B}	0.02±0.011^{B}	0.6±0.351^{A}	0.03±0.011^{B}	0.01±0.002^{B}	0.05 ±0.017^{B}	2.45^{NS}
Mn(mgL^{-1}	0.06±0.0173 ^{BCD}	0.1±0.011^{AB}	0.12±0.03^{A}	0.08±0.0152^{ABC}	0.04±0.0115^{CD}	0.13±0.013^{D}	6.64**

Values are means of triplicate reading and standard error (± SE). Different superscripts in the same row indicate significant differences (P <0.05)

Table 6. Phycoremediation of some nutrients in tap water and Bahr Hadous

Parameters	. Tap water			Bahr Hadous			F value
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	
NH_4-N (mgL^{-1})	1.4±0.328^{B}	2.1±0.404^{AB}	0.7±0.23^{B}	1.4±0.173^{B}	3.5±1.266^{A}	1.4±0.2^{B}	0.66^{NS}
NO_3-N (mgL^{-1})	2.1±0.513^{AB}	0.7±0.115^{B}	1.4±0.208^{B}	2.1±0.513^{AB}	3.5±1.014^{A}	1.4±0.305^{B}	5.37*
PO_4 (mgL^{-1})	0.01±0.002^{B}	0.01±0.001^{B}	0.090±.017^{A}	0.01±0.002^{B}	0.01±0.0023	0.02±0.0026^{B}	15.63**

Values are means of triplicate reading and standard error (± SE). Different superscripts in the same row indicate significant differences (P <0.05)

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المعالجه النباتيه لمياه الصرف الصحي الزراعى ببحر حادوس باستخدام الازولا بيناتا

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الماء ضروري للإنسان وغيره من الكائنات الحية، لكن تلوث المياه أصبح مشكلة كبيرة اليوم. تنتج الأنشطة البشرية الزراعية والصناعية والمنزلية مواد عضوية وغير عضوية متعددة تذوب أو تعلق في الماء. وبالتالي، فإن هدف معالجة مياه الصرف الصحي ذو شقين: تقليل تلوث المياه مع الحفاظ على إمدادات المياه لتلبية الطلب. في تجربة معملية مضبوطة لمدة 15 يومًا، تم استخدام نبات الأزولا لمعالجة مياه الصرف الصحي التي تم جمعها من بحر هادوس، مصر. تم اختباره على ثلاثة مستويات من مياه الصرف الصحي والمياه العادية كعلاج مرجعي (5 و 10 و 20 سم). هدفت الدراسة الحالية إلى تقييم قدرة الأزولا على معالجة مياه الصرف الصحي على أعماق مختلفة. أظهرت نتائج الدراسة انخفاضًا في درجة الحموضة، والتوصيل الكهربائي، والكاتيونات، والأنيونات، وبعض المعادن الثقيلة، والنترات، والفوسفور، مع كون العمق الأمثل هو 10 سم. علاوة على ذلك، تم تقييم فعالية الأزولا في معالجة مياه الصرف الصحي واستخدامها لأغراض الري.

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