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Assessment of Biological Augmentation Technology of Hazardous Pollutants Existing in Drainage Water in Bahr El-Baqar Drain, Egypt

Hanan A. Fouad[1], Rehab M. Hefny[1], Al-moaataz Bellah M. M. Kamel[1], Mohamed Azab El-Liethy[2], Bahaa A. Hemdan[2*]

[1]*Department of Sanitary and Environmental Engineering at Shoubra, Behna University, Benha, Egypt*

[2]*Water Pollution Research Department, Environmental Research Division, National Research Centre, 33 El-Bohouth St., Dokki, Giza 12622, Egypt.*

THE objectives of the present study were to improve the quality of drainage water for reuse through the reduction of COD, BOD, TSS, TN, TP, and ammonia, also the removal of odor and detoxification of toxic compounds. The designed system for the treatment of drainage wastewater collected from Bahr El-Baqar drains was performed. The bioactive bacterial strains were applied in this system and followed by the electrocoagulation process. The phyico-chemical and biological parameters were estimated for raw and treated drainage wastewater and compare the quality of treated drainage water according to law 1948. The results acquired pointed out the level of physicochemical items, and the numbers of bacterial indicators in Bahr El-Baqar drainage wastewater have been decreased after biological augmentation treatment after 6, 12 and 24 h. As well, The pH was around 7.2 and 7.4 after biological treatment (Table 3). Total suspended solid (TSS) declined from 124 mg/L in Bahr El-Baqar drainage water to 88 mg/L, 75.6 mg/L, 63.2 mg/L after 6, 12 and 24 h contact time, Also, TDS declined from 2410 mg/L in Bahr El-Baqar drainage water to 1710 mg/L, 1470 mg/L, and 1229 mg/L after 6, 12 and 24 h contact time, respectively. The current research concluded that the quality of drainage water was improved after the combined process (biologically and electrocoagulation treatment). The present research, therefore, considered that these technologies are economical and eco-friendly approach to be used in drainage water treatment.

Keywords: Biological augmentation, Electrocoagulation, Pollutants, Physico-chemical parameters, Bio-indicators, Bahr El-Baqar drain.

Introduction

Bahr El- Baqar is one of the most polluted drains in Egypt [1]. Bahr El-Baqar drain receives and carries the most significant section of the wastewater (about 3 BCM/ year) into Lake Manzala through a very densely populated area of the Eastern Delta passing through Qalubyia, Sharkia, Ismailia and Port Said Governorates [2]. The discharge of industrial, agricultural and municipal wastewaters in Bahr El Baqar drain which farmer uses it in irrigation led to contamination of environment. These soils receive many kinds of pollutants, especially heavy metals such as lead, cadmium, nickel, and mercury, which are considered the most hazardous[3]. However, the question still not answers yet is "what is the environmental and ecological risk assessment of heavy metals of Bahr El Baqar on sustainable soil resources"? For an ecological risk assessment associated with pollutant exposure in ecosystems, several

*Corresponding author e-mail: bahaa_nrc@yahoo.com, Mobile: +201200997583, Fax: +20233370931
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environmental factors must be considered, such as chemical, physico-chemical, biological, and ecotoxicological parameters. All these variables must be integrated and some indexes have been applied to do it. Varieties of methods have been developed for the risk assessment of heavy-metals as a sediments enrichment factor, index of the geological accumulation and pollution load index [4].

With a growing population and intensified industrial and agricultural activities, the large amounts of untreated urban municipal, industrial wastewater and mixed agricultural and domestic wastes discharge into the river Nile, canals or agricultural drains which become an easy dumping site for all kinds of wastes. The main industrial sectors are oil and soap, starch yeast glucose, pulp and paper, metal industry, plastic and rubber and textile and dyeing [5]. In the irrigated areas the level of applied water is generally higher than necessary to prevent salt accumulation in the root zone of the soil [6]. In a system of drainages (~18000km length), the excess water carrying salts and chemical residues is collected and either pumped into irrigation canals for reuse or pumped into the river Nile or into the northern lakes or the Mediterranean. Using the water twice or even three times increases the salinity especially in drains near the lakes bordering the Mediterranean Sea. As well, in Egypt about 0,9 million Ha of irrigated land were damaged by salt corresponding to about 33% of the total irrigated land [7]. The mixing of drain water with clean water diffuses all kinds of constituents that still have negative environmental and health impacts. Without seasonal flushing floods, the former delta plain surface is now incapable of recycling and or removing agricultural, municipal and industrial waste generated by Egypt's rapidly expanding population. The necessary expansion of the water supply services is not always fitting to the conjugate development of the sewerage system [8].

Nowadays, drainage wastewater treatment and reuse is an attractive option for blocking the gap in water needs, this is due to the diminishing of fresh water resources, rapid industrialization and recognition of new more harmful contaminants. In the last century, wastewater treatment entails the removal of solids (suspended, colloidal and floated), biodegradable organic matters, nutrients and elimination of pathogenic microorganisms[9]. Lately, due to the increased scientific knowledge, wastewater treatment begins to focus on health concepts related to toxic pollutants and pathogens released into the environment[10]. Therefore, extensive wastewater characterization is the key tool to select the proper and effective treatment method. Each treatment method has its own advantages and disadvantages based on pre-treatment requirements, reliability, feasibility, efficiency, cost, operation difficulty, maintenance, practicability, personal skills, foot print, environmental impact, sludge production, scaling up, and the formation of hazardous toxic residues[11]. Thus, the present study was aimed to treatment of Bahr El-Baqardrainage water using combined technology (biological augmentation using bioactive bacterial strains and electrocoagulation processes) for safe reusing of treated effluent in agricultural purposes and irrigation.

Materials and Methods

The objectives of the present study were to improve the quality of Bahr El-Baqar drainage water for reuse through the reduction of COD, BOD, TSS, TN, TP, and ammonia, also the removal of odor and detoxification of toxic compounds. Thus, to achieve these objectives, semi pilot scale was designed for the treatment of wastewater samples collected from drainage wastewater using bioactive bacterial strains and compares the quality of treated drainage water according to law 1948.

Samples sites and collection

Thestudy area is located in northern Egypt, Bahr El Baqar region, between 31°50' to 32°20'longitude and 30°50' to 30°10' latitude (Fig. 1). Environmental protection in Bahr El Baqar region is faced with critical problems due to the increasing population, demolishing natural resources, environmental pollution, land-use planning as well as others [2]. And then, the water quality of drainage wastewater from Bahr El-Baqar drains was biologically and chemically characterized.

Designed system for treatment of drainage wastewater collected from Bahr El-Baqar drains

For obtaining a high quality of wastewater for the Bahr El-Baqr drain, the combined biological augmentation and electrocoagulation processes applied in a semi pilot-scale system. The operation and condition were also completely different, the engineered system consisted of the first tank with dimension 40x60x140 cm filled with 70 L of Bahr El-Baqr drainage water, and the contact time in the first tank was almost 1 hr. After that, the primary treated drainage water after biological augmentation passed to the next process, which known with electrocoagulation. The electrocoagulation process implemented in the system as three tanks, the dimension of each one was 30x30x30 connected with the power supply to provide 30 voltage (5 A). The contact time in each electrocoagulation was 3 min tank. The final treated samples were collected frequently every 12 and 24 hrs for physico-chemical and microbiological analyses according to standard methods[13].

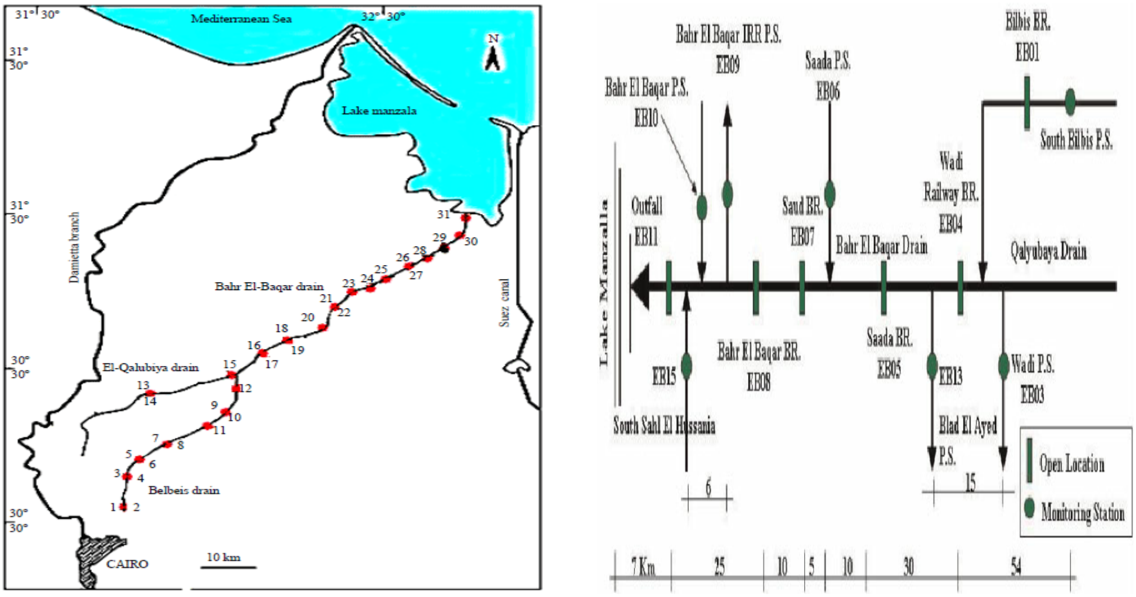

Fig. 1. Mapping and droppings for various samples selected for Bahr El-Bagar drain, Egypt[12].

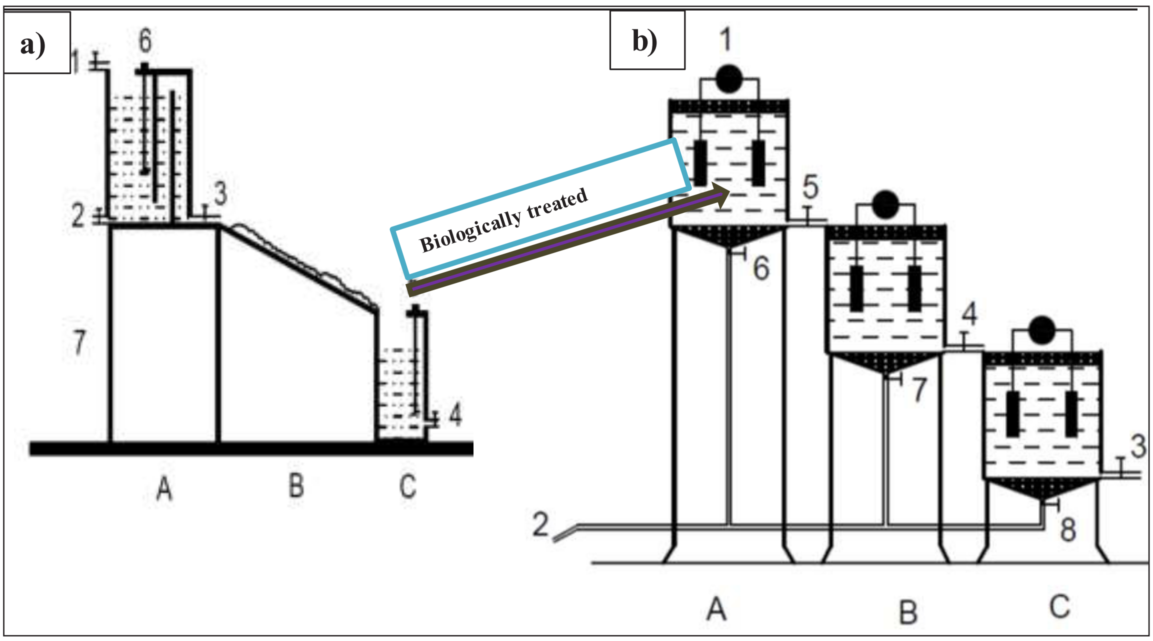

Fig. 2. Schematic diagram of bench scale engineered system for treatment of drainage wastewater collected from Bahr El-Baqar a) biological augmentation process and b) electrocoagulation process.

Characterization of the bioactive bacterial strains (BioWiSH)

From our previous work, the bacterial strains were obtained from a commercial bioactive substance packet known as BioWiSH (BIOWISH Technologies Inc. USA)[14]. The powder was rehydrated in a flask containing 10 mL of phosphate-buffered saline and shaked to ensure proper dissolution. Then 90 mL of double-strength Tryptic Soy Broth (BD, Germany) was added into the vortexed flask to enrich the bacterial population and enhance growth. The flask incubated at 37^{o}C for 18–24 h. Depending on the morphological characteristics, the most frequently isolated bacterial colonies grew on Tryptic Soy Agar (BD, Germany) plates after incubation selected for identification using BIOLOG GEN III (BIOLOG, USA). The selected bacterial colonies inoculated directly into an inoculating fluid (IF). after that, the inoculated suspension distributed into a 96-wells MicroPlate (BIOLOG, USA). This Micro- Plate contains 94 different lyophilized carbons and chemical was utilizing sources. The inoculated MicroPlate incubated at 37^{o}C for the identification of bacterial strains. The identification procedures achieved by comparing with the Biolog's microbial identification systems software in a semi-automated way[15].

Physico-chemical properties of the Bahr El Baqar

Some physical and chemical parameters such as odor, COD, BOD, TSS, TN, TP and ammonia were measured using standard methods [16].

Bacteriological examination of the Bahr El Baqar

Bacterial indicators including fecal coliform and *E. coli* were enumerated using multiple tube fermentation technique according to standard method[16].

Results and Discussion

Biological augmentation process is the addition of a bacterial consortium, as exogenous microorganisms, to accelerate the degradation rate of pollutants[17]. The application of biological augmentation for wastewater treatment is still not widely used on a large scale. In addition to accelerated the activated sludge process by adding *Micrococcus* sp. into bioaugmented sequencing batch reactors for degrading di-n-butylphthalate (DBP) in industrial wastewater. Moreover, Bacillus sp. could be biologically treated into treatment systems for the removal of quinolones from wastewater[18]. Also, total organic carbon was removed through the biological augmentation process using a mixture of two bacterial strains[19].

From our previous published work, it can be found the identified bacterial species, which used as bioactive bacterial strains in biological augmentation for biological treatment of drainage watsewter, were as follows; Bacillus*subtilis* (S1), *Lactobacillus plantarum* (S2), *Pediococcus* spp. From previous study, *Bacillus subtilis* and *Lactobacillus plantarum* have been previously used as indigenous or exogenous pure bacterial strains in wastewater treatment for organic and inorganic pollutants removal [14].

Bahr El-Baqar drain consists of a main drain that starts near the city of Zagazig where it collects the effluents from two secondary drains: the Bilbeis drain and the Qalubeya drain. From Zagazig, the Bahr El-Baqar drain transports water for about 100 km to the Ginka sub-basin in the southeast sector of the Lake Manzala which is located on the north-eastern edge of the Nile Delta. It was estimated that Lake Manzala receives about 60 m^3/s of wastewater from Bahr El-Baqar Drain [20]. In this study, fecal coliform and *E. coli* counts in Bahr El-Baqar were $3.9x10^3$ and $2.0x10^3$ MPN-index/100mL and reached to $2.6x10^3$ and $1.6x10^3$ MPN-index/100mLafter 6 h contact time of biological treatment. Only one log reduction was observed after 12 and 24 h contact times (Table 1).

Regarding concentrations of the physic-chemical parameters and densities of bacterial indicators levels of Bahr El-Baqar drainage water and after biological treatment (run 2) were illustrated in Table (2). The pH, TSS, TDS, COD, and BOD of Bahr El-Baqar drainage water were 7.4, 132 mg/L, 2400 mg/L, 80 mg O_2/L and 27mgO_2/L, respectively. On the other hand, the amount of total phosphorus (TP), ammonia, nitrate, nitrite, TKN and TN of Bahr El-Baqar drainage water were 0.32 mg/L, 5.6 mg/L, 0.25 mg/L, 0.05 mg/L, 11 mg/L and 11.3 mg/L, respectively (Table 2). Moreover, cyanide and phenol were not detected after biological treatment process at 6, 12 and 24 h contact time.

Furthermore, all the physicochemical and bacteriological parameters of Bahr El-Baqar drainage water have been improved after biological treatment and the improvement increases by contact time increases after 6, 12 and 24 h. The pH was around 7.0 and 7.2 after biological treatment (Table 2). Total suspended solid (TSS) declined from 132 mg/L in Bahr El-Baqar drainage water to 96.4 mg/L, 83 mg/L, 72 after 6, 12 and 24 h contact time, Also, TDS declined from 2400 mg/L in Bahr El-Baqar drainage water to 1752 mg/L, 1512 mg/L, and 1320 mg/L after 6, 12 and 24 h contact time, respectively (Table 2). COD decreased from 80mgO$_2$/L to 58mgO$_2$/L after 6 h contact time, 50.4 mgO$_2$/L after 12 h contact time, 44 mgO$_2$/L after 24 h as contact time. BOD decreased from 27 mgO$_2$/L to 23 mgO$_2$/L after 6 h contact time, 24 mgO$_2$/L after 12 h contact time, 22 mgO$_2$/L after 24 h contact time (Table 2 and Fig.2). Likewise, the results, oil and grease decreased from 13 mg/L to 9.5, 8.2 and 7.2 mg/L after 6, 12 and 24 h contact times respectively (Table 2).

TABLE 1. Biological augmentation treatment of Bahr El-Baqar Drain after 6, 12 and 24 h (Run 1).

Parameters	Unit	Raw	Biologically treated effluent with 19 gm/m^3		
			6 hr	12 hr	24 hr
pH	--	7.6	7.2	7.1	7.1
TSS	mg/L	158	110.6	97.96	82.2
TDS	mg/L	2880	2016	1785.6	1497.6
COD	mg/L	96	67.2	59.5	49.9
BOD	mg/L	32.4	30.1	28.2	25
TP	mg/L	0.5	0.3	0.3	0.2
Ammonia	mg/L	6.7	4.7	4.2	3.5
Nitrate	mg/L	0.3	0.2	0.1	0.1
Nitrite	mg/L	0.06	0.04	0.04	0.03
TKN	mg/L	13.2	9.1	8.2	6.8
TN	mg/L	13.56	9.34	8.34	6.93
Oil and grease	mg/L	15.6	10.9	9.7	8.1
D. sulfide	mg/L	1.5	1.1	0.9	0.7
Sulfate	mg/L	294	205.8	182.3	152.4
Chloride	mg/L	1176	823	729	611
Cyanide	mg/L	0.001<	ND	ND	ND
Phenol	mg/L	0.001<	ND	ND	ND
Fecal coliform	MPN/100mL	$3.9x10^3$	$2.6x10^3$	$1.4x10^2$	$1.1x10^2$
E.coli	MPN/100mL	$2.0x10^3$	$1.6x10^3$	$1.1x10^2$	$1.0x10^2$

ND: Not detected

TABLE 2. Biological augmentation treatment of Bahr El-Baqar Drain after 6, 12 and 24 h (Run 2).

Parameters	Unit	Raw	Biologically treated effluent with 19 gm/m^3		
			6 hr	12 hr	24 hr
pH	--	7.4	7.2	7.1	7.0
TSS	mg/L	132	96.4	83	72
TDS	mg/L	2400	1752	1512	1320
COD	mg/L	80	58	50.4	44
BOD	mg/L	27	23	24	22
TP	mg/L	0.32	0.2	0.18	0.11
Ammonia	mg/L	5.6	4.1	3.6	3.1
Nitrate	mg/L	0.25	0.22	0.15	0.1
Nitrite	mg/L	0.05	0.04	0.03	0.02
TKN	mg/L	11	8.1	7.0	6.1
TN	mg/L	11.3	8.36	7.18	6.22
Oil and grease	mg/L	13	9.5	8.2	7.2
D. sulfide	mg/L	1.2	0.9	0.75	0.6
Sulfate	mg/L	245	178.7	154.4	134.6
Chloride	mg/L	980	715.4	617	539
Cyanide	mg/L	0.001<	ND	ND	ND
Phenol	mg/L	0.001<	ND	ND	ND
Fecal coliform	MPN/100mL	$4.6x10^3$	$2.8x10^3$	$4.8x10^2$	$204x10^2$
E.coli	MPN/100mL	$1.6x10^3$	$1.1x10^3$	$2.1x10^2$	$1x10^2$

ND: Not detected

In this study, fecal coliform and *E. coli* counts in Bahr El-Baqar were **4.6x10^3** and **1.6x10^3** MPN-index/100mL and reached to 2.8x10^3 and 1.1x10^3 MPN-index/100mLafter 6 h contact time of biological treatment. Only one log reduction was observed after 12 and 24 h contact times (Table 2).

In case of (run 3), the obtained results cleared that the physicochemical and bioindicatorfeatures of tested water and after biological treatment were presented in Table (3). The pH, TSS, TDS, COD, and BOD of drainage water were 7.6, 124 mg/L, 2410 mg/L, 118 mg O_2/L and 43 mgO_2/L, respectively. While, the level of TP, ammonia, NO_3, NO_2, TKN and TN of drainage water were 43 mg/L, 14.5 mg/L, ND, 17.4 mg/L and 17.4 mg/L, respectively. Moreover, cyanide and phenol were not detected after biological treatment process at 12 and 24 h contact time.

From these results, it can be found that physical, chemical and biological of drainage water have been improved after biological augmentation treatment this lead to thequality of treated water was improved by increasing of contact time after 6, 12 and 24 h. The pH was around 7.2 and 7.4 after biological treatment (Table 3). Total suspended solid (TSS) declined from 124 mg/L in drainage water to 88 mg/L, 75.6 mg/L, 63.2 mg/L after 6, 12 and 24 h contact time, As well, TDS declined from 2410 mg/L in drainage water to 1710 mg/L, 1470 mg/L, and 1229 mg/L after 6, 12 and 24 h contact time, respectively (Table 3). Likewise, the level of COD decreased from 118 mgO_2/L to 84 mgO_2/L after 6 h contact time, 72 mgO_2/L after 12 h contact time, 60 mgO_2/L after 24 h contact time (table 3 and fig.3). BOD decreased from 43 mgO_2/L to 30.5mgO_2/L after 6 h contact time, 27 mgO_2/L after 12 h contact time, 22 mgO_2/L after 24 h contact time. Regarding to the results, oil and grease decreased from 9.4 mg/L to 6.7, 5.7 and 4.8 mg/L after 6, 12 and 24 h contact times respectively (table 3). Likewise, fecal coliform and *E. coli* counts in tested drainage water were 2.8x10^{3}and 1.6x10^3 MPN-index/100mL and reached to 1.6x10^3 and 1.1x10^3 MPN-index/100mL after 6 h contact time of biological treatment. Indeed, only one log reduction was observed after 12 and 24 h contact times (Table 3).

TABLE 3. Biological augmentation treatment of Bahr El-Baqar Drain after 6, 12 and 24 h (Run 3).

Parameters	Unit	Raw	Biologically treated effluent with 19 gm/m^3		
			6 hr	12 hr	24 hr
pH	--	7.6	7.4	7.2	7.2
TSS	mg/L	124	88	75.6	63.2
TDS	mg/L	2410	1710	1470	1229
COD	mg/L	118	84	72	60
BOD	mg/L	43	30.5	27	22
TP	mg/L	0.5	0.4	0.3	0.2
Ammonia	mg/L	14.5	10.3	8.8	7.4
Nitrate	mg/L	ND	ND	ND	ND
Nitrite	mg/L	ND	ND	ND	ND
TKN	mg/L	17.4	12.3	10.6	8.9
TN	mg/L	17.4	12.3	10.6	8.9
Oil and grease	mg/L	9.4	6.7	5.7	4.8
D. sulfide	mg/L	2.4	1.7	1.5	1.2
Sulfate	mg/L	281	199.5	171.5	143.3
Chloride	mg/L	1004	712.8	612.4	512
Cyanide	mg/L	0.002	0.001<	ND	ND
Phenol	mg/L	0.002	0.001<	ND	ND
Fecal coliform	MPN/100mL	2.8x10^3	1.6x10^3	4.6x10^2	2.1x10^2
E.coli	MPN/100mL	1.6x10^3	1.1x10^3	2.2x10^2	1.0x10^2

ND: Not detected

Data presented in Table 4 found that the tested drainage water's physicochemical and bacteriological appearances are demonstrated in Table (4) after biological treatment (run 4). The Bahr El-Baqar drainage water pH, TSS, TDS, COD, and BOD was 7.7, 138 mg / L, 2320 mg / L, 95 mg O_2/L, and 34 mgO_2/L. Bahr El-Baqar drainage wastewater from the other side was 0.8 mg / L, 6.1 mg / L, 0.3 mg / L, 0.05 mg / L, 12 mg / L and 12.35 mg / L respectively for total phosphorus (TP), ammonia, nitrate, TKN, and TN. As regard, cyanide and phenol have not been observed at 6, 12 and 24 h contact time after biological treatment.

Moreover, the results showed in Table 4 indicated that after biological augmentation treatment, all the physical, chemical and bacteriological parameters of drainage water have already been enhanced and the improvement of water quality increased upon 6, 12 and 24 h in preparation time. TSS was dropped significantly from 138 mg / L in Bahr El-Baqar drainage water to 93,84 mg / L, 77, 3 mg / L, 64,8 mg / L after 6, 12 and 24 h contact time. TDS already decreased from 2320 mg / L in Bahr El-Baqar drainage water to 1577 mg / L, 1297 mg / L and 1090 mg / L after 6, 12 and 24 h time intervals, respectively. COD decreased from 95 mgO_2/L to 64 mgO_2/L after 6 h contact time, 53 mgO_2/L after 12 h contact time, 44 mgO_2/L after 24 h time intervals. BOD decreased from 34 mgO_2/L to 23 mgO_2/L after 6 h contact time, 19 mgO_2/L after 12 h contact time, 16 mgO_2/L after 24 h contact time.After 6, 12 and 24 h interaction intervals, oil and grease reduced regularly from 14 mg / L to 9.0, 7.0 and 6.0 mg/ L. Results of Similarly, current investigation demonstrated that, fecal coliform and *E. coli* counts in Bahr El-Baqar were 1.5x10^3 and 1.1x10^3 MPN-index/100mL and extended to 1.4x10^2 and 1.1x10^2 MPN-index/100mLafter 6 h contact time of biological augmentation treatment. Simplythe level of reduced bacterial cells of bacterial indicators after 12 and not detected after 24 h contact times was only one log count (Table 4).

From the findings reported in Table 5, it was observed that even after biological augmentation processing all the physical and chemical and microbiological parameters of drainage water have already been developed and the enhancement of water quality has been showed after 6, 12 and 24 h with contact time. After biological treatment, the pH was about 7.1 and 7.4 (Table 5). Average suspended solid (TSS) decreased to 85 mg/L, 71 mg/L, 57 mg/L after 6, 12 and 24 hours of contact. The concentration of TDS has declined from 2340 mg / L in Bahr El-Baqar drainage water to 1521 mg/L, 1287 mg / L and 1053 mg / L after 6, 12 and 24 hours of contact, respectively. After 6 years, COD dropped from 98 mgO_2/L to 63 mgO_2/L .

TABLE 4. Biological augmentation treatment of Bahr El-Baqar Drain after 6, 12 and 24 h (Run 4).

Parameters	Unit	Raw	Biologically treated effluent with 19 gm/m^3		
			6 hr	12 hr	24 hr
pH	--	7.7	7.4	7.2	7.1
TSS	mg/L	138	93.84	77.3	64.8
TDS	mg/L	2320	1577	1297	1090
COD	mg/L	95	64	53	44
BOD	mg/L	34	23	19	16
TP	mg/L	0.8	0.5	0.4	0.3
Ammonia	mg/L	6.1	4.1	3.4	2.3
Nitrate	mg/L	0.3	0.2	0.1	0.04
Nitrite	mg/L	0.05	0.03	0.02	ND
TKN	mg/L	12	8	6	5
TN	mg/L	12.35	8.23	6.12	5.04
Oil and grease	mg/L	14	9	7	6
D. sulfide	mg/L	1.8	1.2	1.0	0.8
Sulfate	mg/L	222	144	122	95
Chloride	mg/L	880	580	475	387
Cyanide	mg/L	0.002	ND	ND	ND
Phenol	mg/L	0.002	ND	ND	ND
Fecal coliform	MPN/100mL	1.5x10^3	1.4x10^2	9.0x10	ND
E.coli	MPN/100mL	1.1x10^3	1.1x10^2	7.0x10	ND

ND: Not detected

TABLE 5. Biological augmentation treatment of Bahr El-Baqar Drain after 6, 12 and 24 h (Run 5).

Parameters	Unit	Raw	Biologically treated effluent with 19 gm/m^3		
			6 hr	12 hr	24 hr
pH	--	7.5	7.4	7.1	7.1
TSS	mg/L	130	85	71	57
TDS	mg/L	2340	1521	1287	1053
COD	mg/L	98	63	53	44
BOD	mg/L	38	25	21	17
TP	mg/L	0.6	0.4	0.33	0.26
Ammonia	mg/L	6.7	4.3	3.6	2.0
Nitrate	mg/L	0.4	0.2	0.2	0.1
Nitrite	mg/L	0.04	0.02	0.01	ND
TKN	mg/L	15	9.6	8.0	6.0
TN	mg/L	15.44	9.28	8.21	6.1
Oil and grease	mg/L	12	7	6	5
D. sulfide	mg/L	2.1	1.3	1.1	0.9
Sulfate	mg/L	230	140	117	94
Chloride	mg/L	820	500	418	336
Cyanide	mg/L	0.002	ND	ND	ND
Phenol	mg/L	0.002	ND	ND	ND
Fecal coliform	MPN/100mL	$2.3x10^3$	$1.4x10^2$	$1x10^2$	ND
E.coli	MPN/100mL	$1.4x10^3$	90	40	ND

ND : Not detected.

As shown in Table 5, the level of oil and grease have beenreduced from 12 mg/L to 7.0, 6.0 and 5.0 mg/L after 6, 12 and 24 h time intervals, respectively. In the present research, fecal coliform and *E. coli* counts in tested drainage water were $2.3x10^3$ and $1.4x10^3$ MPN-index/100mL and reached to $1.4x10^2$ and 90MPN-index/100mLb after 6 h contact time of biological augmentation approach also reached to $1.0x10^2$ and 40 MPN-index/100mL after 12 h contact time and not detected after 24 h contact times.

Biological treatment of municipal wastewater for reuse in irrigation is highly required, especially with the current global financial and water shortage crises. Biological augmentation appraoch is a simple and cost-effective technology which could be a useful tool in alleviating this challenge[21]. Generally, biological augmentation treatment followed by electrocoagulation showed good pollutants removal from Bahr El-Baqar Drain water. The pH ranged between 7.1- 7.2 after biological treatment and 6.8- 7.0 after electrocoagulation treatment. Moreover, TSS ranged between 71- 97.9 mg/L after biological treatment and ranged between 29 - 39 mg/L after electrocoagulation treatment. Conversely, the level of TDS ranged between 1287-1785 mg/L after biological treatment and 527- 731 mg/L after electrocoagulation treatment (Tables 8 and 9). Chemical oxygen demand (COD) was reduced between 50.4- 72 mg/L after biological treatment and 20-29.5 mg/L after electrocoagulation treatment while BOD was declined from 19 to 28.2 mg/L after biological treatment and between 7.8 to 11.5 mg/L after electrocoagulation treatment (Tables 6 and 7). Apparently, total phosphorus (TP), ammonia, nitrate, nitrite, TKN and TN were also decreased after biological treatment followed by electrochemical treatment (Tables 8 and 9). Oil and grease was decreased between 5.7- 9.7 mg/L after biological treatment while decreased to 2.3-3.9 mg/L after electrocoagulation treatment (Tables 8 and 9). Cyanide and phenol were not detected after both biological and electrochemical treatments (Tables 8 and 9).

Regarding to bacteriological results, it was found that, fecal coliforms was detected between 90-$4.6x10^2$ MPN-index/100mL after biological treatment and 90 -$1.5x10^2$ MPN-index/100mL after electrocoagulation. *E. coli* was ranged between 40-$2.2x10^2$ MPN-index/100mL after biological treatment and 70-110 MPN-index/100mL after electrocoagulation treatment (Tables 6 and 7).

TABLE 6. Biological augmentation treatment of Bahr El-Baqar Drain after 12 h contact time followed by electrocoagulation (EC) (Runs 1, 2 and 3).

Parameters	Unit	Run 1		Run 2		Run 3	
		Biological	EC	Biological	EC	Biological	EC
pH	----	7.1	6.9	7.1	6.8	7.2	7.0
TSS	mg/L	97.9	39	83	34	75.6	30.7
TDS	mg/L	1785	731	1512	619	1470	602.7
COD	mgO_2/L	59.5	24.1	50.4	20	72	29.5
BOD	$mg\ O_2/L$	28.2	11.5	24	9.8	27	11.0
TP	mg/L	0.3	0.1	0.18	0.07	0.3	0.1
Ammonia	mg/L	4.2	0.7	3.6	1.5	8.8	3.7
Nitrate	mg/L	0.1	0.04	0.15	0.06	ND	ND
Nitrite	mg/L	0.04	ND	0.03	0.001	ND	ND
TKN	mg/L	8.2	3	7	2	10.6	4.1
TN	mg/L	8.34	3.04	7.18	2.8	10.6	4.1
Oil and grease	mg/L	9.7	3.9	8.2	3.2	5.7	2.3
D. sulfide	mg/L	0.9	0.3	0.75	0.3	1.5	0.6
Sulfate	mg/L	182.3	74.5	154.4	63	171.5	70.1
Chloride	mg/L	729	282	617	252	612.4	194
Cyanide	mg/L	ND	ND	ND	ND	ND	ND
Phenol	mg/L	ND	ND	ND	ND	ND	ND
Fecal coliform	MPN-Index/ 100 ML	140	90	480	110	460	150
E.coli		110	70	210	100	220	110

TABLE 7. Biological augmentation treatment of Bahr El-Baqar Drain after 12 h contact time followed by electrocoagulation (EC) (Runs 4 and 5).

Parameters	Unit	Run 4		Run 5	
		Biological	EC	Biological	EC
pH	----	7.2	7.0	7.1	7.0
TSS	mg/L	77.3	31.5	71	29
TDS	mg/L	1297	531.7	1287	527
COD	mgO_2/L	53	21.5	53	21.5
BOD	$mg\ O_2/L$	19	7.8	21	8.6
TP	mg/L	0.4	0.1	0.3	0.1
Ammonia	mg/L	3.4	1.3	3.6	1.2
Nitrate	mg/L	0.1	0.04	0.2	ND
Nitrite	mg/L	0.02	ND	0.01	ND
TKN	mg/L	6	2.5	8	3.0
TN	mg/L	٦.12	2.54	8.21	3.00
Oil and grease	mg/L	7	3	6	2.5
D. sulfide	mg/L	1.٠	0.4	1.1	0.4
Sulfate	mg/L	122	50	117	47
Chloride	mg/L	475	194	418	171
Cyanide	mg/L	ND	ND	ND	ND
Phenol	mg/L	ND	ND	ND	ND
Fecal coliform	MPN-Index/ 100 ML	90	ND	100	ND
E.coli		70	ND	40	ND

By concerning, physicochemical treatment options for wastewater such as advanced oxidation, nano-filtration, reverse osmosis or activated carbon, are greatly challenged by the need for extremely high financial resources, especially in large scale applications[22]. Hence, biological treatment using indigenous microorganisms is one of the low-cost solutions for such purposes[23]. However, the indigenous microorganisms in biosolids cannot degrade all pollutants and inactivate pathogens in wastewater. Also, some complex pollutants require a consortium of different microorganisms that may not simultaneously be found in the environment naturally. Thus, despite the success of this approach, using indigenous bacteria in the biodegradation process may be inhibited by abiotic factors like pH, temperature, and redox [24]. This shortfall results in the production of poor water quality; thus, bioaugmentation approaches could be beneficially used in such cases[14].

With regard to the results of the biological treatment, we decided to pursue the biological treatment by electrocoagulation treatment after 12 and 24 h contact time. By applying electrocoagulation approach the current to the medium, electrocoagulation combines coagulation, flotation and electrochemistry to destabilize suspended, caramelized or dissolved contaminants in aaquatic environment [24].

The biological wastewater treatment is a technology that primarily uses bacteria, and possibly other specialty microbes to clean water. When these microorganisms break down organic pollutants for food, they stick together, which creates a flocculation effect allowing the organic matter to settle out of the solution[25]. The advantages of biological treatment are low cost, no or low power needed and low sludge producing [26]. In this study, the ratio between BOD/COD was more than 0.3. It means that the biological treatment for Bahr El-Baqar is the most suitable for treatment. In the present study, all the physicochemical and bacteriological parameters of Bahr El-Baqar drainage water have been improved after biological treatment and the improvement increases by contact time increases after 6, 12 and 24 h. The pH was around 7.1 and 7.2 after biological treatment (Table 1). Likewise, total suspended solid (TSS) and TDS were decline from 158 and 2880 mg/L in Bahr El-Baqar drainage water to 11.6 and 2016 mg/L, 97.96 and 1785.6 mg/L, 82.2 and 1497.6 mg/L after 6, 12 and 24 h contact time, respectively (Table 1). COD and BOD were decreased from 96 and 32.3 mgO_2/L to 67.2 and 30.1 mgO_2/L after 6 h contact time, 59.5 and 28.2 mgO_2/L after 12 h contact time, 49.9 and 25 mgO_2/L after 24 h contact time (table 1 and fig.1). Regarding to the results, oil and grease decreased from 15.6 mg/L to 10.9, 9.7 and 8.1 mg/L respectively after 6, 12 and 24 h contact times.

Indeed, the removal efficiencies of H_2S, COD, BOD_5, total solids (TS), total dissolved solids, total suspended solids, ammonia, nitrate, phosphorus, and oil and grease reached 85, 93.4, 83.5, 37, 49.2, 93.4, 100, 55.7, 76.6 and 76.6%, respectively in the treated effluent after biological treatment and sand filtration[14].

The drain system bears high level of pathogenic organisms similar to those in the original human excreta. There may be several types of pathogens like viruses, bacteria, protozoa and helminthes [27]. By testing for coliform group, especially the well-known *Escherichia coli*, which is a thermotolerant coliform, one can determine if the water has probably been exposed to fecal contamination; bacterial water analysis is a routine check to make sure that the concentration of potentially pathogenic bacteria in drinking water is sufficiently low to say it is safe for human consumption at a reasonable level of confidence. Certainly, the presence of *E. coli* in water is a strong indication of recent sewage or human and animal waste contamination[28]. In this study, typically two bacterial indicators are chosen; fecal coliforms and *E. coli*. Coliforms (and especially *E. coli*) could suggest the possibility of fecal matter contamination of a water supply [24].

Definitely, Bacillus spp. is considered as unique bacteria that perform highly regarding the removal of nitrogen and organics from wastewater. As well, the removal efficiency for total nitrogen and COD after 24 h reached 80 and 71.7%, respectively by Bacillus sp. Also, Bacillus sp. was shown to completely degrade 10 mg/L of nitrite within 14 h at a DO concentration of 5.2 ± 5.8 mg/L [29]. Some studies were applied the bioactive bacterial strains in Biofilters. It is the most common processes for the removal of odor in wastewater treatment plants due to their low cost and low energy requirements. Microorganisms in biofilters can oxidize odorous gases such as H2S and NH3 into non-odorous gases under aerobic conditions[30]. Characterization of TSS, COD, and BOD in wastewater are considered the major parameters for pollution level evaluation and as efficiency indicators for any treatment process[31]. Moreover,the removal efficiency of COD reached 85.9, 87.7 and 93.4% after sedimentation, gravel biofiltration and sand biofiltration, respectively. Furthermore, the removal efficiency of BOD reached 62, 71.4 and 83.5% after sedimentation, gravel biofiltration and sand biofiltration, respectively. Moreover, DO in the influent (0.28 mgO_2/L) was improved to 0.56 mgO2/L after sedimentation, 3.2 mgO_2/L after gravel biofiltration and 6 mgO2/L after sand biofiltration[21].

Sedimentation is a significant stage in wastewater treatment for the removal of total solids and suspended solids, also leading to decreased organic loads usually expressed by COD and BOD (Jover-Smet et al., 2017). In this experiment, total solids, TDS, and TSS were removed by 23.1, 25.9, and 90%, respectively after the sedimentation stage. The removal efficiencies were increased to 29.8, 46.6 and 91.1% after gravel biofiltration and reached 37.5, 49.2, and 93.4% in the treated wastewater after sand biofiltration.In addition, the removal of organics, nitrogen, and suspended solids from municipal wastewater through sedimentation followed by biofiltration. They found that 97% of ammonia (NH3) was oxidized through the biofiltration process[32]. Herein, after sedimentation, the removal efficiency of organic pollutants reached between 80 and 90%, and suspended solids values were low (25 mg/L). The authors also found that the residual of soluble organic pollutants was treated when the settled water flowed through the biofiltration units. Hence, the removal efficiency of organic and inorganic pollutants from wastewater is improved by the addition of exogenous bacterial consortia, while the increased enzymes produced accelerate the biodegradation process. These enzymatic reactions play a critical role in thewastewater treatment process through biological augmentation of the complex pollutants and converting them into simple, nontoxic compounds[25]. The contained lactic acid bacteria were antagonistic against other microorganisms, including enteric pathogens. In previous studies, the removal of total and fecal coliforms from wastewater in batch reactors by the effect of the augmented bacteria was confirmed by comparing the removal efficiency of coliforms with control reactors (no augmented bacteria were added)[14]. They found that coliform counts in the control increased between 120% after 24 h and 800% after 7 days and these studies attributed this increase to the absence of augmented bacteria that could have antagonistic effects against the coliforms group [33].

Conclusion

Biological augmentation using bioactive bacterial strains and electrocoagulation technologies for degrading the organic pollutants exists in drainage wastewater treatment are most effective for decreasing the threatening problems of these hazardous pollutants and reducing COD, and BOD parameters exist in wastewater. Indeed, it is used to improve the quality of treated effluent, minimize sludge production, and for safe discharge of treated effluents into the environment. Definitely, the selection of these affordable and efficient treatment technologies depends on the characterization of wastewater, biodegradability, available footprint, quality of treated effluent required, costs, availability of funds, and personal skills. From the obtained results, it can be found that the level of physicochemical items has been decreased in biologically treated effluent and become within the limit of Law 48 for wastewater quality for agricultural purposes and irrigation. Thus, the current investigation recommends the applying of these combined approaches because it is affordable, convenient, and mighty in removing all harmful pollutants during drainage wastewater treatment.

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