Desalination and Water Treatment
www.deswater.com

doi: 10.1080/19443994.2015.1099472

57 (2016) 19131–19139
September

Taylor & Francis
Taylor & Francis Group

Cost–benefit analysis of using treated sewage for landscaping in Lahore city, Pakistan

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Received 6 April 2015; Accepted 17 September 2015

ABSTRACT

In Pakistan, wastewater production is 4.43 billion m^3/year. The best way to deal with this problem is to reuse water in irrigation of crops and gardening, after proper treatment. Wastewater reuse for landscaping is practicable in Lahore because high quality water is not necessary for landscaping purposes. Wastewater was treated at lab scale to reuse for landscaping in Lahore for cost-effective algal treatment to reduce the cost with analysis of Algal species *Sirogonium sticticum* and *Chaetomorpha sutoria* effectively removed the phosphates (99.9%), sulfates (99.6%), nitrates (100%), coliforms (99%), and color (92.8%), etc. After the reduction of chemicals, percentages of color (92.8%) and all physical and chemical parameters are within the current law in Pakistan. It was estimated that the total energy cost of landscape irrigation for Race Course park, Lawrence garden, and Gulshan-e-Iqbal park was about USD 86,409.72/year and average cost of fertilizers for landscaping in major parks of Lahore is USD 1,528.49/year. Reusing of this wastewater can save this cost in addition to the saving of almost five cusecs of drinkable fresh water. The cost of collecting wastewater in oxidation ponds is very less because most of the drains pass through these parks, and pumping water through these drains requires very less economic consumption.

Keywords: Wastewater treatment; Algal treatment; Landscaping; Cost analysis

1. Introduction

The population of Pakistan has increased to 190 million since 2011–2014, and now the population of Pakistan is 202 million [1]. Because of overburdened population and less development of water resources, per capita water availability which was 5,300 m^3 has now been reduced to 1,100 m^3 since the last five years. The situation is even worse in small towns, where the per capita water availability is already below 1,000 m^3/year [2]. Due to exponential increase in water demand, the water table of Lahore has declined from 300 to 700 feet, which means now deeper digging is required to extract water to fulfill the increasing demands [3]. In Pakistan, 4.43 billion cubic meter (BCM) wastewater is produced annually, comprising of 3.06 BCM municipal and 1.37 BCM industrial wastes [4], and only 1% of the industrial wastewater and about 8% of domestic wastewater is treated by municipal treatment plants before discharging into natural water sources [5]. Wastewater contains

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different pathogens, inorganic and organic pollutants, anions, and cations, which are posing serious health threats to the farmers and consumers [6].

All the issues discussed above linked with the conventional wastewater treatments systems worldwide raised the interest for the development of biological treatment systems, which is thought to be an efficient solution to the current problem. Use of algae as an economical way of treating wastewater gained popularity in late 1960s [7]. The growth of algae in oxidation ponds is of great value because of its photosynthetic oxygen production [8]. Algae-based municipal wastewater treatment systems are mainly used for nitrogen and phosphorous removal [9].

One way to avoid problems related to water scarcity and wastewater irrigation is to reuse water after proper treatment. Worldwide practice of reusing wastewater for agricultural and landscape irrigation is receiving attention because it cannot only reduce the amount of water needs to be extracted from natural water sources, but it also solves the problem of proper disposal of wastewater to the environment [10]. In urban areas, wastewater reuse for landscaping is practicable because water used for landscaping does not need quality as high as that of drinking water. Landscape irrigation includes the irrigation of parks, play grounds, golf courses, school and residential yards, and green belts. Aquaculture and fish farming is a growing industry in Pakistan contributing about 1% to the GDP of Pakistan. Treated wastewater can be used for fisheries and shrimps culture, which will help to enhance the growth of this industry in water-scarce regions [11].

In this article, municipal wastewater treatment was carried out with tertiary biotreatment using algal cultures in stabilization ponds to define and compare a cost–benefit analysis for the use of fresh water and reusing of waste water for landscaping in Lahore city.

2. Materials and methods

2.1. Study area

The total study area was urban Lahore that comes under Lahore development authority (LDA), Water and Sanitation Agency (WASA), and Parks & Horticulture Authority (PHA). More than 850 small and large parks of Lahore city (Pakistan) are under the control of PHA, where large quantity of fresh water is being used for the irrigation purposes.

2.2. Samples collection and storage

Water sampling was done from main streams of three drains of Lahore city: Nishat colony drain, Mian Mir drain, Samanabad, and Lahore city drain. Samples were collected in plastic cans and tightly sealed. Initial tests were performed instantly after the sample collection, and then rest of the tests were performed in the laboratory without any pretreatment.

2.3. Algae collection and storage

Algae were randomly collected from the Shama drain near Shama cinema, Lahore and the other one was collected from Botanic garden of GC University. After collection, they were identified in laboratory under electron microscope and cultured in the beakers containing wastewater until the start of the experiment. Algal sample taken from Botanic Garden of GC University was a mixture of two types of algae, *Sirogonium sticticum* and *Chaetomorpha sutoria* and algal sample taken from Shama drain was of one type, *Zygnema* sp.

2.4. Experimental design in summers

The wastewater samples were treated in May. After taking the initial readings of all the parameters, the treatment process was started. Each drain sample was treated with two different algae. Each pond was filled with 3 L of wastewater and then 30 g wet weight of algae was added in each pond and mixed well. These ponds were then placed on the roof. Retention time in square ponds ranged from 2 to 4 d. Samples for testing were collected after 2 and 4 d from square ponds.

2.5. Evaporation rate

The average temperature in May was 38–40˚C. The evaporation rate was regularly measured in all the beakers after every 24 h. The water level in each beaker was kept constant by the addition of distilled water.

2.6. Analytical techniques

Temperature, pH, dissolved oxygen (DO), Turbidity and Electrical Conductivity (EC) were determined with the help of digital meters (metric method) as mentioned in the APHA standard methods for wastewater [12]. The portable meter HI 98129 was used to measure the pH and EC of wastewater. The Analite NEP 160 was used for the turbidity determination and DO was measured with the portable waterproof DO meter, HANNA, HI 9145.

Total suspended solids (TSS) were determined according to the APHA standard method. Spectrophotometer (721 VIS spectrophotometer) was used to analyze nitrates, phosphates, and sulfates in the wastewater. They were determined according to the standard methods of APHA, 4500-NO_3^{-1} Spectrophotometric method, 4500-P Ascorbic acid method and 4500-SO_4^{2-} Turbidimetric method, respectively [12]. The Chloride (Cl) contents in the wastewater were determined through the Idiometric method, in accordance with the standard methods (4500- Cl C). Biological Oxygen Demand (BOD) was determined in accordance with the standard methods (5210 B-5 d BOD test). Chemical Oxygen Demand (COD) was determined with the help of medium- and low-range vials. Calorimeter (Lovibond, ET 108) was used to find out the COD value in mg/L. Total coliforms were determined by the standard method (9221-C) through multiple fermentation technique.

2.7. Removal efficiency

The removal efficiencies of nutrients from the treated wastewater were calculated with the help of formula (Eq. (1)), in terms of percentage removal efficiency:

$$\%\text{age Removal Efficiency} = (\text{Output} - \text{Input}) / \text{Output} \times 100 \quad (1)$$

2.8. Data collection from PHA and WASA

The required data for the cost analysis and usage of water were collected from PHA and WASA. Different parks of Lahore such as Lawrence Garden, Race Course Park, and Gulshan-e-Iqbal Park were visited for this purpose.

3. Results and discussions

3.1. Characteristics of sewage water

The characteristics of sewage water to be treated are shown in Table 1. These water samples were collected from different drains of Lahore.

3.2. Physical parameters of treated wastewater in summer

The results of physical characterization including Temperature, DO, EC, pH, Turbidity, TDS, and TSS of treated wastewater of Nishat colony drain (Drain 1), Mian mir drain (Drain 2) and Samnabad drain (Drain 3) with two different algal species e.g. *S. sticticum* and *C. sutoria* (Algae S1) and *Zygnema* sp. (Algae S2) are given in Table 2.

Drain 1: The temperature of all the samples remained within the range of average temperature of May (38–40˚C) throughout the treatment duration. The temperature in May was favorable for the growth of algae in sunny days. In this month, algae grew well in the ponds and the required nutrient removal efficiency

Table 1
Initial wastewater characteristics of Nishat colony drain (Drain 1), Mian mir drain (Drain 2), and Samanabad drain (Drain 3) in summer

Parameters	Units	Summer readings		
		Drain 1	Drain 2	Drain 3
DO	mg/L	1.96	1.99	1.04
EC	µs	636	630	673
pH	–	6.69	6.66	6.66
Turbidity	NTU	80.99	105	86
BOD	mg/L	100	120	120
COD	mg/L	121	167	171
TDS	mg/L	409	410	445
TSS	mg/L	970	1,034	980
Cl	mg/L	76.68	70.29	108.63
PO_4^{1-}	mg/L	45	58	48
SO_4^{2-}	mg/L	35	32	34
NO_3^{1-}	mg/L	0.886	1.772	0.886
Salinity	–	0.3	0.3	0.3
Fecal Coliforms	MPN/100 ml	350	160	350
Color	% Absorbance	0.204	0.246	0.267

Table 2
The performance of *S. sticticum* and *C. sutoria* (Alage S1) and *Zygnema* sp. (Algae S2) treating wastewater of Nishat Colony Drain (Drain 1), Mian mir drain (Drain 2), and Samanabad Drain (Drain 3)

Physical characterization of wastewater at different treatment duration

			24 h		48 h		72 h		96 h	
Parameters	Drains	Initial	Algae S1	Algae S2	Algae S1	Algae S2	Algae S1	Algae S2	Algae S1	Algae S2
Temp (°C)	1	38.3	38	3.1	38	38.2	38	38.2	38.2	39.1
	2	38.2	38	38.1	37	37.1	38.2	38.4	39	39.9
	3	38.6	3.4	38.7	38	38.3	39	39.2	39	39
DO (mg/L)	1	0.96	3.9	3.8	6.77	6.42	8.2	8.7	10.23	10.1
	2	0.99	3.4	3.91	6.77	6.45	8.12	8.18	11.25	10.5
	3	0.04	3.2	3.78	6.78	6.42	7.65	8.4	111.75	110.31
EC (µs)	1	636	523	546.1	483.3	490	345	367	253.3	267
	2	630	540	566.1	488	489	324.7	376	221.6	249
	3	673	566	501.9	491	487	342.1	398	271	289
pH	1	6.69	7.1	7.5	9.77	9.10	9.0	9.3	9.74	9.45
	2	6.66	7.1	7.8	9.74	9.45	8.12	8.65	9.60	9.32
	3	6.66	7.6	7.98	9.76	9.32	9.1	9.0	9.89	9.32
Turbidity (NTU)	1	80.99	70.2	70.5	25.6	28.1	14.3	14.5	2.93	2.9
	2	105	89.1	79.9	27.1	28.1	15.3	27.3	3.10	5.29
	3	86	65.4	77.3	15.7	19.3	12.6	11.9	2.3	2.43
TDS (mg/L)	1	508.8	409	445	290	301	280	298	152	160.2
	2	504	368	400.4	293	305	209	267	193	155
	3	538.4	345.5	476.1	295	303	206	267	163	154
TSS (mg/L)	1	370	240	232	67.1	76.3	45.7	56.1	30.1	32.1
	2	334	209	176	54.9	67.3	39.1	45.9	20	25.1
	3	380	207	265	53.1	66.3	35.6	38.5	24	29.1

was obtained after 96 h of treatment. After 96 h, algal growth was inhibited because of the unavailability of the nutrients, and thus, the system was closed for further activity. Sampling was done after every 24 h. DO showed an increasing trend throughout the treatment duration because of the photosynthetic activity of algae, e.g. 6.77 and 10.23 mg/L after 48 and 96 h, respectively, after treatment with algal sample 1. In algal sample 2, it was increased up to 6.42 and 10.1 mg/L after 48 and 96 h, respectively. EC showed a decreasing trend after every treatment day. Initial EC was 636 µs and decreased to 483.3 and 253.3 µs after 48 and 96 h, respectively, upon treatment with algal sample 1, while it reduced to 496 and 267 µs after 48 and 96 h, respectively, when treated with algal sample 2. As the EC of the samples decreased, the pH of all the samples increased with time. The Initial pH was 6.69 and it increased up to 9.74 after 96 h of treatment with algal sample 1. Algal sample 2 showed an increase in the pH up to 9.45 after 96 h of treatment. Turbidity, total dissolved solids (TDS), and TSS were reduced after treatment with two algal samples. Turbidity was reduced to 25.6 NTU after 48 h of treatment with algal sample 1 against the initial value of 80.99 NTU. Then, it showed further decrease after 96 h of treatment e.g. 2.93 NTU. Algal sample 2 reduced the turbidity to 28.1 NTU and then to 2.9 NTU after 48 and 96 h of treatment, respectively. TDS were also reduced to 152 and 160.2 mg/L after treatment with algal sample 1 and 2, respectively, at the end of the treatment against the initial value of 508.8 mg/L. TSS were significantly removed from the drain water after treatment e.g. 30.1 and 32.1 mg/L against initial value of 370 mg/L treated with two algal samples, 1 and 2, respectively, after 96 h of treatment.

Drain 2: DO showed an increasing trend throughout the treatment duration because of the photosynthetic activity of algae e.g. 6.77 and 11.25 mg/L after 48 and 96 h, respectively, after treatment with algal sample 1. In algal sample 2, it increased up to 6.45 and 10.5 mg/L after 48 and 96 h, respectively. EC showed a decreasing trend after every treatment day. Initial EC was 630 µs and decreased to 488 and 221.6 µs after 48 and 96 h, respectively, when treated with algal sample 1, while it reduced to 489 and 249 µs after 48 and 96 h, respectively, when treated with algal sample 2. As the EC of the samples decreased, the pH of all the samples increased with time. The Initial pH was 6.66 and it increased up to 9.60 after 96 h of treatment with algal sample 1. Algal sample 2 showed an increase in the pH up to 9.32 after 96 h of treatment. Turbidity, TDS, and TSS were reduced after treatment with two algal samples. Turbidity was reduced to 27.5 NTU after 48 h of treatment with algal sample 1 against the initial value of 80.99 NTU. Then, it showed further decrease after 96 h of treatment e.g. 3.10 NTU. Algal sample 2 reduced the turbidity to 28.1 NTU and then to 5.29 NTU after 48 and 96 h of treatment. TDS were also reduced to 193 and 155 mg/L after treatment with algal sample 1 and 2, respectively, at the end of the treatment against the initial value of 504 mg/L. TSS were significantly removed from the drain water after treatment e.g. 54.9 and 67.3 mg/L against initial value of 370 mg/L treated with two algal samples, 1 and 2, respectively, after 48 h, and reduced to 20 and 25.1 mg/L treated with algal sample 1 and 2, respectively, after 96 h of treatment.

Drain 3: DO showed an increasing trend throughout the treatment duration because of the photosynthetic activity of algae e.g. 6.78 and 11.75 mg/L after 48 and 96 h, respectively, after treatment with algal sample 1. In algal sample 2, it increased up to 6.42 and 10.31 mg/L after 48 and 96 h, respectively. EC showed a decreasing trend after every treatment day. Initial EC was 673 µs and decreased to 491 and 271 µs after 48 and 96 h, respectively, when treated with algal sample 1, while it reduced to 487 and 289 µs after 48 and 96 h, respectively, when treated with algal sample 2. As the EC of the samples decreased, the pH of all the samples increased with time. The Initial pH was 6.66 and it increased up to 9.89 after 96 h of treatment with algal sample 1. Algal sample 2 showed an increase in the pH up to 9.32 after 96 h of treatment. Turbidity, TDS, and TSS were reduced after treatment with two algal samples. Turbidity was reduced to 15.7 NTU after 48 h of treatment with algal sample 1 against the initial value of 86 NTU. Then, it showed further decrease after 96 h of treatment e.g. 2.3 NTU. Algal sample 2 reduced the turbidity to 19.3 NTU and then to 2.43 NTU after 48 and 96 h of treatment. TDS were also reduced to 163 and 154 mg/L after treatment with algal sample 1 and 2, respectively, at the end of the treatment against the initial value of 538.4 mg/L. TSS were significantly removed from the drain water after treatment e.g. 53.1 and 66.3 mg/L against initial value of 380 mg/L treated with two algal samples, 1 and 2, respectively, after 48 h, and reduced to 24 and 29.1 mg/L treated with algal sample 1 and 2, respectively, after 96 h of treatment.

3.3. Chemical and biological parameters of treated wastewater in summer

BOD was reduced to its low range in water after 96 h. The efficiency of BOD removal by Algal sample is shown (Fig. 1). In all the samples, BOD5 was reduced after every sampling. 18.4% BOD from drain 1, 21.4% from drain 2, and 19.7% from drain 3 was removed after 24 h and 28% from drain 1, 39.16% from drain 2, and 37.5% from drain 3 after 48 h, and 40.2% from drain 1, 48.7% from drain 2, and 50.3% from drain 3 was removed after 72 h. At the end, 60, 70.8, and 79.16% removal was observed after 96 h from drain 1, 2, and 3, respectively by algal sample. COD has also shown a decreasing trend in all the samples as shown in Fig. 2 e.g. 14.2, 34.7, and 24% from drain 1, 2, and 3, respectively, and 36.36% COD from drain 1, 50.28% from drain 2, and 53.2% from drain 3 was removed after 48 h of treatment. After 96 h, more COD was removed from all the three samples e.g. 61.2% from drain 1, 73.05% from drain 2, and 78.9% from drain 3.

The efficient removal of phosphates (PO_4^{1-}) after the treatment is shown in Fig. 3. It showed a gradual decrease after every treatment day e.g. 32.1, 33.5, and 30.9% from drain 1, 2, and 3 respectively, and 64.4% PO_4^{1-} from drain 1, 79.3% from drain 2, and 79.5% removal from drain 3 were removed after 48 h of treatment. After 96 h, almost all the PO_4^{1-} was removed e.g. 99.9% from drain 1, 96.5% from drain 2, and 99.9% from drain 3.

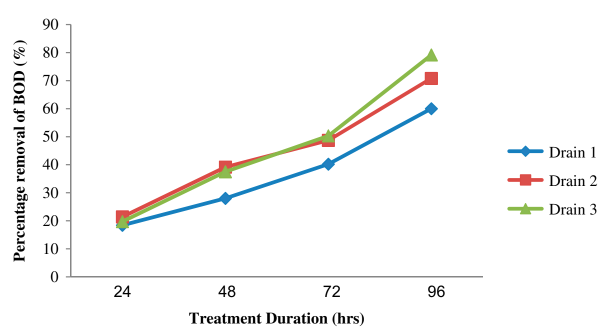

Fig. 1. The performance of *S. sticticum* and *C. sutoria* treatment, in removing BOD (%) from the wastewater samples.

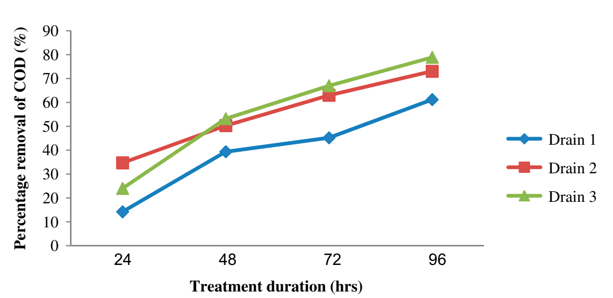

Fig. 2. The performance of *S. sticticum* and *C. sutoria* treatment in removing COD (%) from the wastewater samples.

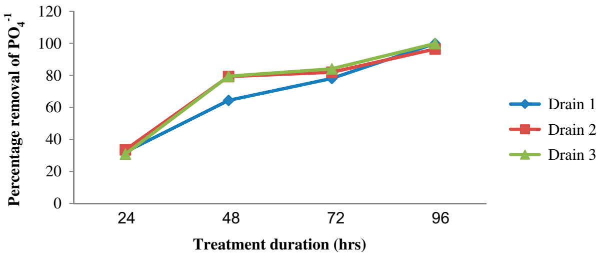

Fig. 3. The performance of *S. sticticum* and *C. sutoria* treatment in removing PO_4^{1-} (%) from the wastewater samples.

Both algal species showed 99.4% SO_4^{2-} removal from drain 1, 99.8% from drain 2, and 99.7% from drain 3 (Fig. 4). All the samples showed 100% in rest of the sampling days. Algal species showed 100% removal of nitrates from drain 1, 95.25% from drain 2, and 95.19% from drain 3 after 24 h, indicating both species have a high nitrate removal capacity. After 48 h, every sample showed 100% nitrate removal (Fig. 5). The % color absorbance was checked to observe the color removal efficiency of samples by the algae. Both algae showed good results in removing the color of wastewater. As the TDS and TSS were removed from the water, they started to get clear with every passing day, except for few cases in which algae showed its own color. The percentage removal of color was 76.5% from drain 1, 69.1% from drain 2, and 71.6% from drain 3 after 24 h of treatment by algal sample 1 (Fig. 6), while 87.4% from drain 1, 89.5% from drain 2, and 90.1% from drain 3 after 48 h. About 90.2, 93.4, and 94.9% removal was observed after 96 h. All the samples were clear at the end of the treatment.

Fecal coliforms were significantly removed in May by algae. The percentage removal efficiency by *S. sticticum* and *C. sutoria* is shown in Fig. 7, which shows 100% removal of coliforms at the end of 96 h treatment. The first testing was done after 48 h which shows 65% removal from drain 1, 69% from drain 2, and 68% from drain 3. After 72 h, 92% removal from drain 1, 88% from drain 2, and 90% from drain 3 was observed. The algae showed good efficiency in removing the coliforms. At the end of 96 h treatment, all samples were totally free from fecal coliforms. The reason for fecal coliform removal is the presence of enough sunlight which increases the temperature of water and disinfected it. The high pH is also one of the reasons for the removal of fecal coliforms from the water because at pH > 9.5 fecal coliforms become inactive in water [13]. The results of May in fecal

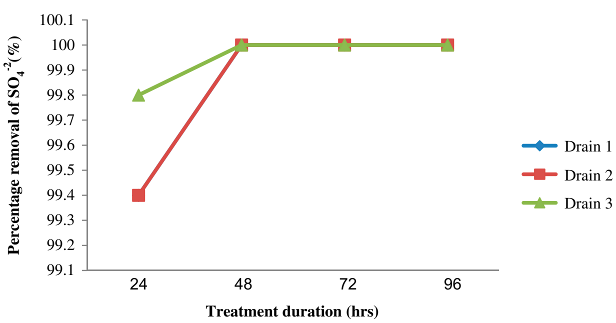

Fig. 4. The performance of *S. sticticum* and *C. sutoria* treatment in removing SO_4^{2-} (%) from the wastewater samples.

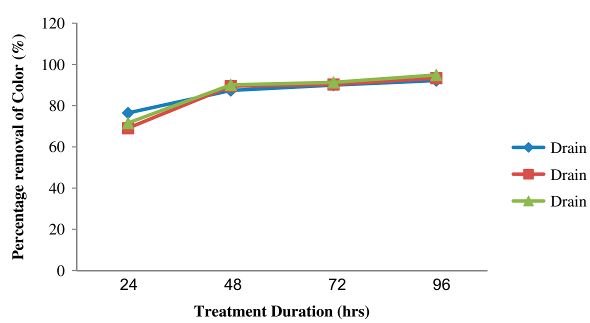

Fig. 6. The performance of *S. sticticum* and *C. sutoria* treatment in removing color (%) from the wastewater samples.

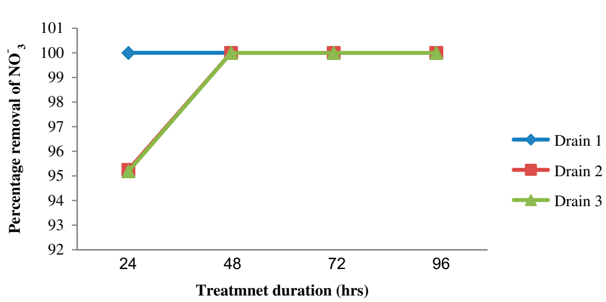

Fig. 5. The performance of *S. sticticum* and *C. sutoria* treatment in removing NO_3^- (%) from the wastewater samples.

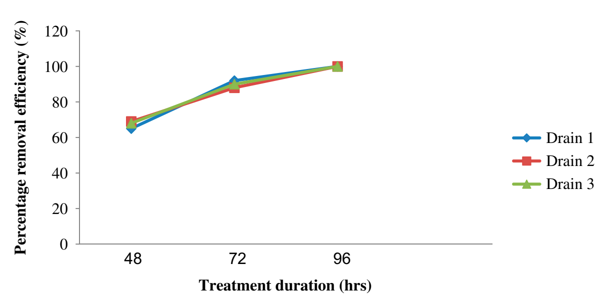

Fig. 7. The performance of *S. sticticum* and *C. sutoria* treatment in removing fecal coliforms from the wastewater samples.

Table 3
Total energy cost of water pumping for landscaping in different parks

Parks	No of water sampling appliances	Time period of running a motor/d (h)	Total energy consumed per day (units)	Total energy cost per day	Annual energy cost/year (Rs)	Total energy cost (Rs)
Lawrence garden	Motors of total 200 horse power (hp)	4 (Summer)	596 (Summer)	10,728	21,45,600	30,36,600
		2 (winter)	300 (winter)	5,400	8,91,000	
Race Course Park	1 motor of 150 horse power (hp)	8 (Summer)	894	16,092	32,18,400	45,68,433
		4 (winter)	447	8,046	13,27,590	
	6 motors total of 30 horse power (hp)	2	30	61.49	22,443.85	
Gulshan-e-Iqbal Park	2 turbines of total 100 horse power (hp)	8 (Summer)	596	10,728	21,45,600	27,69,071
		4 (winter)	298	5,364	85,060	
	11 motors total of 55 horse power (hp)	2	81.95	1475.1	5,38411.5	

coliform removal are better than in winter months because summer days are sunnier so that temperature of the water was high enough for disinfection.

All the wastewater samples were treated successfully within the targeted time by algae. Algal species showed good results in removing contaminants from the water. These results confirm previous studies of efficiency of wastewater algal ponds in treating the wastewater. DO in all the drain water samples increased throughout the treatment duration (Table 2). This is because of the photosynthetic activity of green algae present in water in the presence of sunlight and nutrients. This activity shows a sudden increase in the DO of wastewater with an increase in the algal productivity, when nutrients are present in sufficient amount [14]. With an increase in the algal photosynthesis, an increase in the pH was also observed by all the samples. It is due to the consumption of CO_2 and HCO_{3-} by algae which results in an increase in pH up to >11 [15,16]. Turbidity, TSS, and TDs were significantly reduced in all the samples. The results showed decreasing trend throughout treatment duration, despite few variations which were due to the dust particles added to water due to wind and growth of algal cells. The samples showed removal of nitrates, sulfates, and phosphates at the end of the treatment [16]. These results show that the algae used in the experiment has nutrient removal capacity in all the seasons.

3.4. Cost of water pumping for landscaping in major parks of Lahore

Energy cost of water pumping for landscaping in three major parks of Lahore e.g. Lawrence Garden, Race Course Park, and Gulshan-e-Iqbal Park was calculated with the help of data collected from PHA. The total area of Lawrence garden is 141 acres and there are 4 motors of 20, 20, 60 and 100 hp, respectively, to pump out water for landscaping in the whole garden. Each pump runs at an average for 5 h/d to give water to all areas of the garden. Table 3 shows the total energy cost of landscaping in the Lawrence Garden, Race Course Park, and Gulshan-e-Iqbal Park. The energy consumption in summers and winters is different according to the length of the day and rate of evaporation. The total energy unit consumption is 596 units in summer and 300 units in winter, which costs about 10,728 Rs/d in summer and 5,400 Rs/d in winter. The total energy cost of landscape irrigation is about >3 million/year.

The total area of the Race Course Park is 100 acres and two major water consuming attractions are waterfall and a lake because of which the water pumping costs are more as compared to rest of the two gardens. There is only one motor of 150 hp used for pumping of water for the waterfall. This water is then transferred to the whole park for landscape irrigation. In summer, the motor runs for about 8 h a day and uses 894 units of electricity which costs

Table 4
Average cost of fertilizers for landscaping in major parks of Lahore per year

Fertilizers	Unit price/50 kg (Rs)	Use of bags/ year	Price/year (Rs)
Urea	1,600	20	32,000
DAB	3,050	40	122,000
NPK	1,300	40	5,200
Total			159,200

Table 5
Annual water usage for landscaping in major parks of Lahore

Location	Motors	Water flow rate/s (Cusec)	Flow rate (m^3/sec)	Flow rate (m^3/min)	Flow rate (m^3/h)	Flow rate (m^3/d)	Flow rate (m^3/year)
Lawrence	4	3.25	0.0919	5.514	330.84	5,293.44	1,932,105.6
Race Course	1	4.5	0.1274	7.644	458.64	5,503.68	2,008,843.2
Gulshan-e-Iqbal	1	2	0.0566	3.396	203.76	2,445.12	89,246.88

16092 Rs/d. In winter, the motor runs for about 4 h a day and uses 447 units which costs 8046 Rs/d. Along with this motor, there are 6 small motors of 5 hp and run for average 2 h each, utilizing 30 electricity units, and costs 61.49 Rs/d. Total energy cost of this irrigation system is >4 million/year. Gulshan-e-Iqbal Park also has a lake, which results in more water consumption. The total land area of this park is 66 acres and 2 turbines of 50 hp each, which run for 8 h a day utilizing about 596 units of electricity in summer and 298 units in winter. Eleven small motors of 5 hp each are also used to pump water for watering the park. The total cost of water pumping in the park is >2 million/year.

These values can vary from time to time according to the seasons and cost of electricity. These were the obvious expenses of each park/year, but there are some other costs like maintenance cost, labor, and generators' electricity consumption at the time of emergencies, and most important is the cost of fertilizers.

3.5. Cost of fertilizers for landscaping

Table 4 shows the average cost of fertilizers for landscaping in major parks of Lahore. Both organic and synthetic fertilizers are used in some major parks. Three types of fertilizers are used e.g. Urea (CH_4N_2O), DA (Diammonium phosphate, $(NH_4)_2HPO_4$), and NPK, a compound fertilizer containing Nitrogen, Phosphorous and Potassium (N, P, K). The total cost of fertilizers in one park of about 100–150 acres is 159200 Rs/year. The cost is variable, according to the requirement of the park or plants and unit price of a fertilizer bag. This cost can be minimized using treated wastewater for landscaping purposes. Six days of treatment in winter and 4 d in summer can completely remove all the nutrients from the wastewater, but once the nutrients are within the permissible limits of wastewater use for landscaping, wastewater can be reused. It will provide essential nutrients to the plants which will enhance their growth.

Annual usage of fresh water by three major parks of Lahore is been calculated in Table 5. The values are calculated according to the number of motors in a park and their water flow rate (Cusecs/s). Estimated total usage of water is calculated in m^3 (cubic meter) for each garden. In Lawrence garden, about 2 million m^3 water is pumped to water the plants and landscapes. In Race course park, the usage of water is more because of the waterfall and lake e.g. >2 million m^3 and Gulshan-e-ravi park uses about 89 thousand m^3 annually. If this water is replaced by the treated wastewater, then this much water can be saved, and it can solve the country's issues of freshwater shortage [17].

4. Conclusions

Treatment of sewage with two different algal samples in ponds in summer is found to be very effective in removing excessive nutrients and contaminants from the wastewater. The cost of pumping water for landscape irrigation in parks of Lahore can easily be saved using wastewater. The cost of collecting wastewater in oxidation ponds is very less because most of the drains pass through these parks and pumping water through these drains requires very less energy consumption. Moreover, the cost of fertilizers can also be reduced by reusing treated wastewater for landscaping. The fresh water by this treatment system can be used for drinking purposes in communities where fresh and safe water is not available. It can be recommended that this study can be applied to major parks of Lahore to check the efficiency of this system in saving the cost of energy and fresh water usage. The process can be started with the construction of small ponds and then to the larger shallow ponds for the successful implementation of this study in the field.

Acknowledgments

Authors are very thankful to GCU for providing funding facilities for research.

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