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APPLICATION OF WASTE STABILIZATION POND'S EFFLUENT ON CULTIVATION OF ROSES (*ROSA DAMASCENA* MILL)

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Abstract

The study focuses on the use of Waste Stabilization Ponds (WSP) effluent for irrigation and also aims to compare the efficiency of effluent with the Hoagland solution. Results revealed that the number of flowers, size of flower and the petals per flower increased by the use of both Hoagland solution and treated effluent while the height of plant and the fresh weight of flowers were increased significantly by the Hoagland solution only. Moreover, the leaves showed high concentration of reducing and non-reducing sugars as compared to flowers whereas, only the leaves of plants which were treated by the ponds effluent had low content of reducing sugars as compared to leaves of untreated plants serving as controls. The variation in chlorophyll content was similar to that of reducing and non-reducing sugars. In addition, leaves of plants that were treated by pond's effluent showed highest concentration of total phenol content. It is concluded that treated effluent is as effective as Hoagland for the irrigation of rose. Additionally, the use of treated effluent for irrigation reduces the demand of fresh water and the use of inorganic fertilizers for the commercial production of roses.

Introduction

Rose, the most popular flower belongs to the family Rosaceae, the genus *Rosa* is widely cultivated and contains over 150 species and 1400 varieties (Gault & Synge, 1971). Pakistan earns about 0.72 million dollars from the export of rose flowers. To achieve growth and flowering, roses require adequate amount of fertilizers and other micronutrients (Feigin *et al*., 1991; Ghaffoor *et al*., 2000).

In a rapidly expanding city such as Karachi with a current population of over 18 millions a huge amount of domestic and industrial wastewater is generated and is eventually dumped into the sea without any treatment. Alternatively, this wastewater can be managed and recycled for society benefits (Safi *et al*., 2005). The treated wastewater can be applied for irrigation of field crops and even better yields can be obtained compared to fresh water irrigation (Khan *et al*., 2008, 2009; 2010; 2011; Safi *et al*., 2005; Pollice *et al*., 2004). Treated wastewater is being used in many countries throughout the world as a reliable source of water which can fulfill the gap between supply and demand of irrigation water (Oron *et al*., 2007).

Treated wastewater may prove to be a potential economic asset by contributing to the water resources and the expansion of irrigated agriculture. In addition, it provides an alternative solution to the problem of indiscriminate disposal, thereby protecting environment and public health (Fonseca *et al*., 2007, Papadopoulos & Savvides, 2003; Feigin *et al*., 1991).

Waste stabilization ponds (WSP) are inexpensive and reliable alternative means to biochemical and mechanical system of wastewater treatment, particularly in the tropics (Curtis & Mara, 1994, Alcalde *et al.*, 2003; Ensink *et al.*, 2007). Low operation and maintenance costs coupled with effective pathogen removal have made WSP technology a popular method worldwide (Mara & Pearson, 1998; Alcalde *et al*.,2003).

The requirement of municipal water supply to Karachi is increasing rapidly due to growing population and presently approximately 600 MGD is supplied of which >350 MGD ends up as wastewater. A significant portion of the drinking water is also taken away for agricultural and industrial use. Most of the wastewater is discharged into the sea through Lyari and Malir rivers virtually without treatment. This practice has led to multiple environmental, health and economic impacts in that it causes marine pollution, marine food contamination with microorganisms of health significance and loss of precious water.

The objectives of the present study were 1) to test the suitability of WSP effluent for the production of roses, 2) to assess the potential of nutrient supply, in particular NPK by the WSP effluent compared to the half strength Hoagland solution containing known amounts of nitrogen, phosphorus and potassium.

Material and Methods

The two waste stabilization ponds used in the present study are available at Karachi University Campus. The technical details are given in Table 1.

The ponds are trapezoidal in shape of equal dimensions and are lined with concrete at the bottom as well as the sides. The ponds are connected in series and the outlet is available at a depth of 1.8 m. The primary ponds are connected with the influent sump which receives the raw domestic waste water through underground sewerage line of Karachi Water and Sewerage Board. The secondary pond is likewise connected with the effluent sump.

Collection and analysis of samples: The samples of influent and the effluent were collected twice a month and analysed for the following parameters in accordance with APHA, (Anan., 2005) for organic matter content, total Kjeldahl nitrogen (TKN), potassium, and Total phosphate. The stem, leaves and flowers of the plants were also analysed for reducing and non reducing sugars and were estimated by Nelson's modified Somogy's method (Nelson, 1944). In addition, chlorophyll a and chlorophyll b were estimated in accordance with Arnon (1949), total phenols using the method of Dihazi *et al.*, (2003) and total proteins were determined in the leaves of plants by the methods described by Lowry *et al*., (1951).

Table 1. Technical detail of waste stabilization pond system at Karachi University Campus

S. No	Parameters	Characteristics
1.	Pond area (bottom)	$53 m^2$
2.	Pond area (WSP)	$69 m^2$
3.	Pond area (average)	$61 m^2$
4.	Outlet for effluent	1.8m
5.	Influent sump capacity	$203 m^3$
6.	Effluent sump capacity	$67 m^3$
7.	Pond volume at 1.8 m depth	$127 m^3$
8.	Average total retention time	2 days
9.	Total average hydraulic load	$650 m^3$ /day (approx.)
10.	Total average BOD_5 load	250mg/l

(Based on average BOD_5 load of 250 mg/l; Khan & Ahmed 1992; Khan & Khan 2007)

Pot experiments: Before the effluent was used for irrigation of pots, the effluent was subjected to the analysis of above mentioned parameters. The soil in which rose plants were cultivated was sandy, pH 7.7, water holding capacity 34.2%. Earthen pots of 23.5cm diameter were used having sand of approximately 4.75kg. Each pot contained one plant of rose (*Rosa damascena* Mill var summer damesk). The plants were 6 months old acquired from a local nursery.

The three treatments given are as follows: Treatment A: half strength Hoagland solution (500 ml containing N=105ppm, K=127.5ppm and P=15.5ppm) was given twice a month while the pots were watered on alternate days with 500 ml fresh water; Treatment B: pots were watered with 500 ml WSP effluent on alternate days. Treatment C: control pots were watered with 500 ml fresh water on alternate days. The treatments were applied for a period of 90 days. Thus, the total amount of Hoagland solution used was $0.03m^3$ and tap water used was $0.042m^3$ for Treatment A. Whereas the total amount of treated WSP effluent (Treatment B) used was $0.045 m^3$ and the tap water (Treatment C) was $0.045m^3$.

The pots were arranged in a randomized complete block design on a wooden bench. Treatments and controls were replicated five times each.

Statistical analysis: Data of individual variables were subjected to two-way analysis of variance ANOVA (Zar, 1999). As a follow up of ANOVA, Duncan's multiple range test was also performed.

Results

The Waste Stabilization Ponds (WSP) effluent designated as liquid fertilizer was utilized as a source of irrigation water for roses. The NPK and total organic matter (mg/l) analyses of the WSP effluent is presented in Table 2.

The vegetative characteristics of Roses (*Rosa damascena)* using three treatments are presented in Table 3 and the biochemical characteristics are presented in Table 4.

A critical evaluation of the results outlined in Table 3 clearly demonstrate that both Hoagland solution and treated effluent significantly increased ($p<0.05$) the number of flowers, size of flowers, the number of petals/flowers were increased significantly by ponds effluent and Hoagland solution ($p<0.05$). However height was increased significantly ($p<0.05$) by Hoagland solution only. It is apparent from the Fig. 1 that both reducing sugars and non-reducing sugars were consistently higher in the leaves of roses as compared to stems and flowers. Only reducing sugars content in leaves was significantly lower ($p<0.05$) in treated effluent as compared to controls. Chlorophyll content and the amounts of reducing and non-reducing sugars with Hogland and WSP effluent treatment did not differ significantly. On the other hand, total phenol content of leaves was significantly ($p<0.05$) elevated by the WSP effluent.

Table 2. Quantities of NPK values of effluent collected on different dates for the feeding of roses (*Rosa damascena*).

Dates	Total kjeldahl nitrogen (mg/l)	Phosphate phosphorus (mg/l)	Potassium (mg/l)	Organic matter (mg/l)
10-2-2007	23.52	2.84	6.17	608
16-2-2007	28.39	2.59	6.15	582
13-2-2007	25.63	3.16	6.28	579
02-3-2007	21.37	3.34	5.77	613
08-3-2007	23.28	3.29	5.84	574
14-3-2007	24.26	2.85	6.51	577
21-3-2007	16.32	2.91	7.24	565
28-3-2007	18.15	3.06	6.83	615
04-3-2007	17.29	3.17	7.05	623
11-4-2007	16.25	5.25	7.18	585
17-4-2007	21.38	3.49	7.20	573
04-4-2007	22.56	5.36	7.31	565
Min-Max	16.25-28.39	2.59-5.36	6.62-7.31	565-623
Average	21.53	3.44	6.62	588.25

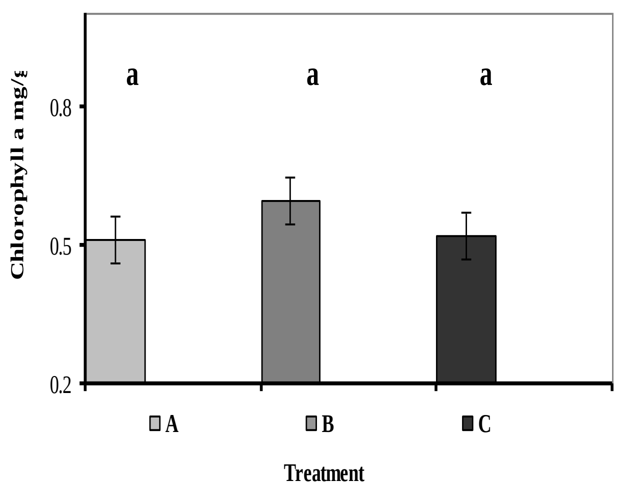
The average available nitrogen in the treated effluent was 21.53 phosphate phosphorous 3.44 and potassium 6.62 while total organic matter content was 588.25 mg/l.

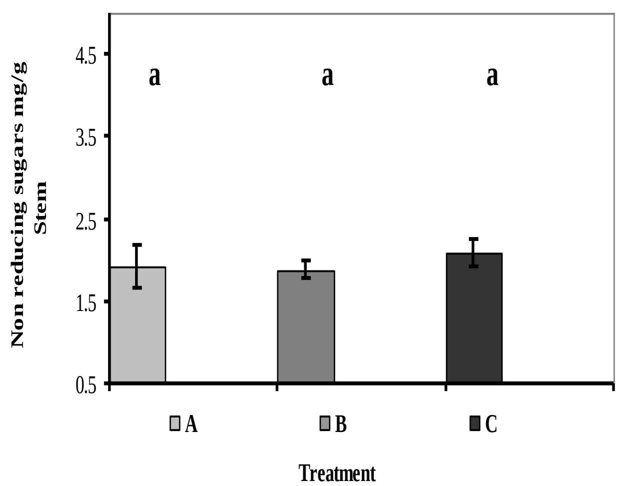
Table 3. Vegetative characteristics of Roses (*Rosa damascena*) using Hoagland solution and treated effluent from waste stabilization ponds. Means followed by a different letter in a row are significantly different (p <0.05).

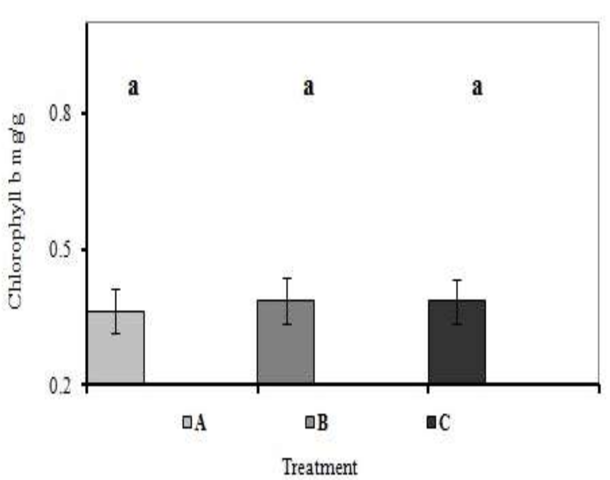
Plant characters	Control	Hoagland solution	Treated effluent
Height of plants (cm)	62.4 ± 4.7 a	73.1 ± 8.3 b	65,8 ± 5.1 a
Diameter of plants (cover) cm	53.8 ± 5.2 a	56.3 ± 6.4 a	57.2 ± 6.8 a
Number of flowers	6.5 ± 0.4 a	8.2 ± 0.3 b	7.6 ± 0.5 b
Size of flower (cm)	5.8 ± 0.3 a	6.7 ± 0.2 b	6.8 ± 0.2 b
Number of petals/ flower	16.4 ± 0.6 a	22.2 ± 1.4 b	20.1 ± 0.2 b
Number of leaves/plant	42.0 ± 4.5 a	45.3 ± 3.0 a	44.6 ± 4.2 a
Fresh weight of flower (g)	4.3 ± 0.7 a	5.1 ± 0.5 b	4.6 ± 0.9 a
Pedicel length (cm0	4.5 ± 0.6 a	4.6 ± 0.3 a	4.6 ± 0.4 a

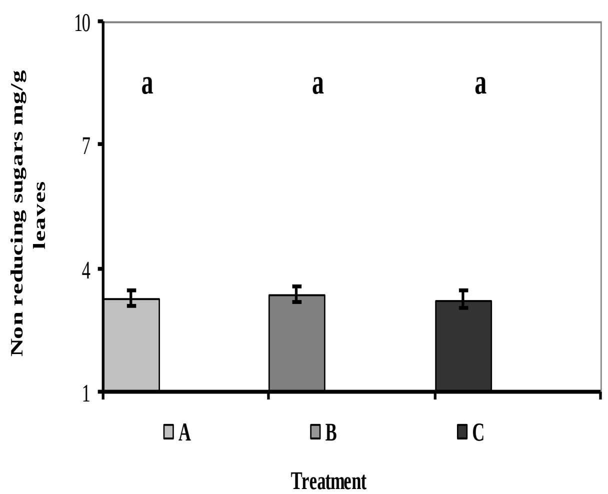
Table 4. Biochemical characteristics of Roses (*Rosa damascena*) using Hoagland solution and treated effluent from waste stabilization ponds. Means followed by a different letter for a given plant part are significantly different (p<0.05).

Sr. #	Biochemical characters mg/gm	Control			Hoagland solution			WSP effluent		
		Stem	Leaves	Flower	Stem	Leaves	Flower	Stem	Leaves	Flower
1.	Chlorophyll a	-	0.512a ± 0.13	-	-	0.596a ± 0.11	-	-	0.52a ± 0.15	-
2.	Chlorophyll b	-	0.363a ± 0.08	-	-	0.386a ± 0.06	-	-	0.384a ± 0.15	-
3.	Reducing sugars	4.08a ± 0.21	6.14a ± 0.21	4.20a ± 0.18	4.31a ± 0.16	6.32a ± 0.31	4.12a ± 0.20	3.86a ± 0.13	5.68b ± 0.18	4.32a ± 0.09
4.	Non-reducing sugars	1.92a ± 0.26	3.27a ± 0.14	2.16a ± 0.28	1.88a ± 0.11	3.38a ± 0.14	2.09a ± 0.06	2.14a ± 0.16	3.24a ± 0.22	2.28a 0.15
5.	Total phenols	-	322a ± 21	-	-	317a ± 20	-	-	345b ± 13	-
6.	Total proteins mg/g fresh weight	-	4.39a ± 0.28	-	-	4.45a ± 0.22	-	-	4.36a ± 0.25	-









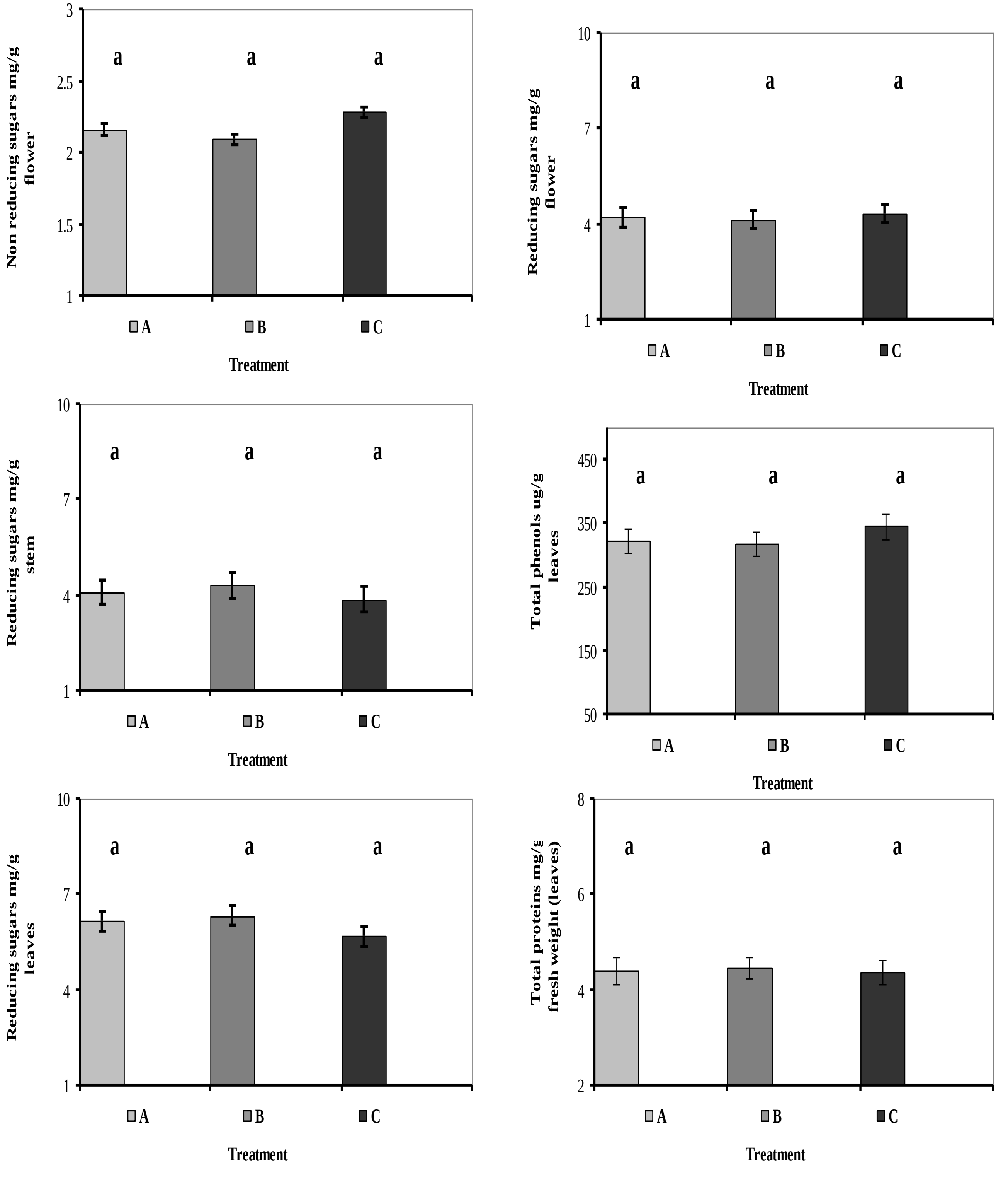


Fig. 1 Effect of treated effluent and Hoagland solution on biochemical characteristics of stem, leaves and flower of roses.

Discussion

The total NPK applied to each pot as a result of irrigation with half strength Hoagland solution was 66.31, 29.36 and 80.42 ppm. Whereas, WSP effluent applied in pots for irrigation contain NPK as 101.94, 16.29 and 31.35ppm for a period of 90 days. These quantities applied through WSP effluent are within the range required by crop plants (Hinkle & Garrot, 1965).

The number of flowers, size of flower and number of petals/flower were increased both by the Hoagland solution as well as the treated effluent over the controls (tap water). Haq *et al.,* (1999) demonstrated that application of potassium alone increased the number of flowers while potassium together with nitrogen enhanced the height of plants as well number of petals/flower.

Young *et al.,* (1986) found greater height and number of flowers following application of nitrogen to rose plants grown in pots. Number and size of rose flowers were markedly elevated when grown in sand culture using NPK solution (Tanaka, 1985). Ghaffoor (2000) demonstrated increase in the number of flowers/plant with the application of N and K @20 and 10 g urea and postash respectively. The increased number of petals/flower in treated effluent over the controls could also be attributed to the presence of high organic matter in wastewater that can improve the soil structure and availability of nutrients (Brady & Weil 2008). Generally, it is argued that the increase in the reproductive output of a crop irrigated with treated effluent results because of the following processes: i) application of treated effluent results in higher nutrients inputs (Overman, 1981), ii) higher uptake and accumulation of nutrients mainly of N and P (Vazquez-Montiel *et al*., 1996) and iii) occurrence of macro and micronutrients in the effluent which can neutralize the undesirable effect of high Na concentrations in treated effluent (Al-Jaloud *et al*, 1995). In the present study the treated effluent contained high values of nitrogen compared to Hoagland solution which indicates the effective use of WSP effluent for the cultivation of commercial roses.

Conclusions

The WSP effluent generated through waste stabilization ponds developed at the University of Karachi proved to be almost as effective as the Hogland nutrient solution and gave a good yield of roses. Since the effluent is sufficiently rich in NPK nutrients, the cost of inorganic fertilizer can be saved. The most significant advantage in the utilization of WSP effluent is that the environmental and health problems of discarding it into nearest water bodies can be avoided. Additionally, considerable quantities of fresh water can be saved for human consumption.

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