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Plant Communities along the Sewage Effluents Channels of Lyari River in Pakistan

M. Zafar Iqbal[1], Damian Gill[1] and Muhammad Shafiq[1, 2]

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ABSTRACT: The vegetation around the Lyari river was mostly dominated by monocotyledonous species viz *Paspalidium geminatum*, *Cyperus laevigatus*, *Chloris barbata* and *Aeluropus lagopoides*. Nineteen species were recorded on the heap area forming six plant communities, whereas, on the plain area seven species with five communities were observed. *P. geminatum* was the most dominant species on both areas, which indicated its tolerance to sewage pollutant. Edaphic characteristics of both areas (pH, $CaCO_3$, organic matter, Na^+, K^+, Pb^{++}, Zn^{++}, Cu^{++}) showed a significant correlation with the vegetation types. High soil pH, exchangeable sodium and potassium, zinc, copper with low calcium carbonate and organic matter were observed on the plain as compared to the heap area. However, a similar range of lead level was found on both areas. The availability of copper increased with the increase in soil pH on both areas. The availability of copper concentration was found above the toxic permissible limit of 150 ppm on both areas which ranged from 200 to 640 ppm. The concentration of zinc fell under the permissible toxic level and did not exceed 300 ppm.

KEY WORDS: Heavy metals, Plant communities, River, Sewage, Effluents, Soil characteristics.

INTRODUCTION

Karachi, the most densely populated city with more than nine million people along with haphazard industrial growth, produces a large amount of toxic sewage effluents without proper pretreatment. Only 2 % of the total sewage produced receives some treatments. The remaining 98 % is untreated discharged into the river. The contamination of underground and surface water produces serious problems to the ecology of vegetation which is growing near to the drains of polluted effluents channels of the Lyari river. The raw sewage as well as the industrial effluents are allowed to flow into dry streams of the area. The localities along the streams have been converted into an open area. Malir and Lyari rivers which were once a bed, with lush green vegetation and with all forms of life abundant in them including fish, but now with the population growth on both sides, have been converted to stinking stream.

There are several different kinds of phytotoxic chemicals in the sewage effluents, which have produced pround effects on the safety of water, natural flora and fauna. Most of these waste effluents containing very high degree of organic impurities and toxic inorganic substances. The volume of the industrial waste effluents is increasing several times as fast that of sewage as the result of growing per capita output of goods and increasing degree of processing per unit products (Iqbal and Munir, 1988).

1. Department of Botany, University of Karachi, Karachi-75270, Pakistan.
2. Corresponding author.

Effluents from towns and cities are main source of damage to river plants from pollution. Many works have described the damages to vegetation caused by industrial effluents, and particularly the water plants have been affected (Kullberg, 1974; Kurimo, 1970). Roberts (1954) and Besch and Roberts - Pichette (1970) also observed the adverse effects of polluted effluents on aquatic submerged plants. In Greece, Kapetaniosa *et al.* (1988) found that the level of heavy metals in compost in river Athens from household refuse was higher with respect to other areas, as compost was originating from municipal waste. The effect of sewage sludge on the heavy metal content of soil and plant tissues was also reported by Macklean *et al.* (1988). In another study, Pervez and Ronald (1988) found a significant effect of heavy metals on soil catalase activity and interaction between biological activity and zinc in soil structure. Chaney *et al.* (1977) observed that plant accumulation of heavy metal and phytotoxicity resulted from utilization of sewage sludge compost on grassland.

The lower harbor in Karachi is actually a channel which is 2.5 km long, 900 meter wide and on average 8.2 meters deep. On the northern side of the harbor lies the mouth of the Lyari river, which is very shallow and characterized by mangrove swamps. The pollutants emanating from about 800 industrial units of Karachi are dumped into Lyari river which later pass through the lower Harbor into the sea (Saifullah and Moazzam 1978). Along with other sources the inflow of Lyari river water into the sea, which contains domestic, municipal, industrial and chemical toxic materials, produces hazardous effects on marine life and plays an important role in the contribution of marine pollution, too.

In Karachi, few works have been published on the effects of sewage effluents on plants. However, the observation on the plant communities of polluted industrial drainage channels of Karachi, phytosociological studies around the polluted disposal channels of industrial areas and ecology of vegetation near to drains of polluted effluents industrial areas of Karachi were conducted by Iqbal and Qadir (1974), Iqbal *et al.* (1983) and Iqbal and Munir (1988), respectively. The vegetation along the sewage effluents channels of Lyari river has not been studied yet.

The aim of the study was to identify vegetation types along the bank of Lyari river, and to relate them with effluent resulting from both industrial and domestic sewage pollutants.

MATERIALS AND METHODS

The vegetation along the banks of waste disposal drains in Lyari river was randomly sampled by rectangular quadrats measuring 2 x 1/2 meter in size. Overall 100 sites were studied covering an area of 4 kilometers in Gulshane-e-Iqbal. Out of the 100 sites, 46 were studied on plain area, while 54 sites were sampled on heaps by method of Braun-Blanquet (1932). Soil samples were obtained from each site at a depth of 30 cm with soil augur. These samples were brought in the laboratory in polythene bags for chemical analysis. Three soil samples from each sites were obtained which were thoroughly mixed as one composite soil sample. These soil samples were dried at 80℃ for 24 hours, ground and sieved to remove particles greater than 1 mm. One gram of soil was put into a 250 ml beaker, 10 ml concentrated nitric acid was added and the mixture was evaporated to dryness on a hot plate. After cooling, this procedure was repeated with a second aliquot of nitric acid. After this, 10 ml concentrated HCl was added to the residue and warmed at 40-50℃. The mixture was filtered through Watman No. 54 filter paper, the residue was washed with 1N HCl and the filtrate volume was made up to 100 ml. The solution were run on atomic absorption spectrophotometer (Model PERKIN ELMER 23380) for the determination of lead, zinc and copper. pH of the soil was determined by direct pH reading meter (Jenway PHM6). Calcium carbonate was determined by acid neutralization methods of Qadir *et al.* (1966), while organic carbon was obtained by placing soil in furnace at 400 - 500 ℃ for five hours (Byers *et al.* 1978). Sodium and potassium were determined by Flame photometer (Model Corning 410).

RESULTS

The vegetation on the banks of the polluted channels of Lyari was mostly dominated by herbaceous plants. The plain ground was not floristically rich as compared to the heap area. The composite values of soil characteristics and vegetation analysis are summarized in Tables 1 and 2. Nineteen species were reported on the heap as compared to seven on the plain area (Appendix A and B). Eleven different types of plant communities were distinguished on the basis of percentage dominance. Out of eleven communities, six were found on the heaps and five on the plain area. The species with low cover (less than 10 %) were not included. On the basis of floristic composition and average percentage cover of each species, *Paspalidium geminatum*, *Prosopis juliflora* and *Solanum surrattense* formed pure population on the heap area. *P. geminatum* had a wide range or occurrence in stands and was found 14 times on the heap and 22 times on the plain areas, respectively.

Edaphic characteristics of both areas (soil pH, $CaCO_3$, organic carbon, sodium, potassium, lead, zinc and copper) showed a correlation with the vegetation types. A correlation was found between vegetation types and soil pH on both plain and heap areas (Tables 1 and 2). *P. geminatum* was the most common and widely distributed species along the waste effluent with soil pH from 6.4 to 6.6 in the study areas. It formed pure populations at pH 6.4 on plain area and at pH 6.6 on heap area, respectively. *S. surratense* as a pure population was found at pH 6.7. *A. lagopoides* formed an association with *Cenchrus ciliaris* at pH 7.5 on the plain area. However, *A. lagopoides* in association with *P. juliflora* was found at low pH 6.6. The amount of organic carbon content on both heap and plain areas ranged from 11 to 30 % (Table 2). *Cenchrus - Paspalidium* community was found at the highest percentage of organic carbon (30 %) on the heap area as compared to the plain area. *P. geminatum* was found at same percentage (21%) of organic carbon on both areas. The soils contained moderate to high calcium carbonate (2 to 20 %) on both heap and plain areas. *Mollugo lotoides* in an association with *Chloris barbata* was found at the lowest $CaCO_3$ (12%) on the heap area. The stands dominated by *Aeluropsus chloris* was found at the lowest $CaCO_3$ (2%) on the plain area as compared to the heap area. A correlation was also found between sodium and potassium and vegetation types. A lot of variation occurred in sodium concentration (16 to 8889 ppm). *P. geminatum* formed pure population at 2914 and 8889 ppm of sodium on plain and the heap areas, respectively. *P. juliflora* formed pure population at the high concentration of sodium (5356 ppm), whereas, *S. surrattense* formed pure population at the lowest Na^+ (16 ppm) on the heap area. *Cyperus laevigatus* either dominant

Table 1. Effect of soil characteristics on vegetation of heap area soil.

Name of communities	Cover%	NOS	pH	OC%	$CaCO_3$ %	ppm Na^+	K^+	Pb^+	Zn^+	Cu^{++}
Paspalidium geminatum	47	15	6.6	21.3	16.1	2914	381	24	74	490
Prosopis juliflora	55	3	6.4	19.3	15.9	5356	448	25	20	350
Solanum surratense	30	1	6.7	23.6	20.0	16.3	483	15	30	500
Cenchrus-Dacty	80-20*	1	6.4	29.0	15.3	2600	167	10	10	640
Mullogo-Chloris	5-25*	1	6.5	21.0	11.6	2250	483	20	60	500
Cenchrus-Paspalidium	30-10*	1	6.6	30.2	13.6	306	417	15	30	300

NOS = Number of stands of occurance of community.
OC% = Organic carbon percentage.
* = Cover of second species.

Table 2. Effect of soil characteristics on vegetation of plain area soil.

Name of communities	Cover%	NOS	pH	OC%	$CaCO_3$ %	ppm Na^+	K^+	Pb^+	Zn^+	Cu^{++}
Paspalidium geminatum	88	22	6.4	21.0	19.5	8889	271	10	200	320
Aeluropsis-Prosopis	60-20*	1	6.6	18.2	9.6	2033	317	15	50	360
Aeluropsis-Chloris	57-40*	1	7.5	15.8	2.3	967	100	10	10	400
Cyperus-Limenium	50-15*	2	6.5	11.0	12.5	6705	242	20	150	200
Limenium - Cyperus	27-26*	3	6.8	13.6	11.0	667	800	35	200	300

NOS = Number of stands of occurance of community.
OC% = Organic carbon percentage.
* = Cover of second species.

or codominant on the plain area was found at a wide range of potassium concentration (242-800 ppm). *P. geminatum* formed pure population at 271 ppm of potassium on plain area and 381 ppm on heap area, respectively.

The soil of both areas showed more or less the same concentration of lead and did not show great variation. *P. geminatum* and *P. juliflora* formed pure population at 24 and 25 ppm of lead concentration on the heap area, respectively, while *Chloris barbata* in association with *Dactyloctenium aegyptium* was found at 10 ppm of lead on the plain area. The highest concentration of lead (35 ppm) was found in association with *Limenium - Cyperus* community on the plain area.

A lot of variation was found in zinc concentration (10 - 74 ppm) on the heap area. *P. geminatum* formed pure population at the highest (74 ppm) on the heap area, while *Chenchrus-Dactyloctenium* was found at the lowest zinc concentration (10 ppm) on the heap area. The stands in which *P. geminatum* and *Limeium-Cyperus* were dominant had a high concentration of zinc (200 ppm) on the plain area. Amount of zinc was also found slightly higher in stands of plain as compared to the heap areas. The level of zinc concentration fell within the permissible toxic level and did not exceed 300 ppm on both areas. Copper was also another important element, which showed a correlation with vegetation types. *C. ciliaris* and *D. eagyptium* were at the highest concentration of copper (640 ppm). *P. geminatum* formed pure population at 490 ppm of copper on the heap area. *A. lagopoides* formed an association with *C. barbata* at highest concentration of copper (400 ppm), whereas, *C. laevigatusin* association with *L. indicum* was found at the lowest concentration of copper (200 ppm). The level of copper concentration was found above the toxic permissible limit (150 ppm) on both heap and plain areas which ranged from 200 to 640 ppm.

Appendix A: Species recorded on the plain area.
1. *Paspalidium geminatum* (Forssk.) Stapf
2. *Eclipta prostrata* (L.) L.
3. *Aeluropus lagopoides* (L.) Trin. ex Thw.
4. *Prosopis juliflora* Swartz.
5. *Cyperus laevigatus* L.
6. *Limenium indicum* Stock ex T. Anders.
7. *Mullogo lotoides* (L.) O. Ktze.

Appendix B: Species recorded on the heap area:
1. *Aeluropus lagopoides* (L.) Trin. ex Thw.
2. *Paspalidium geminatum* (Forssk.) Stapf.
3. *Dactylotenium aegyptium* (L.); P. Beauv.
4. *Prosopis juliflora* Swartz.
5. *Solanum surattense* Burm. f.
6. *Mullogo lotoides* (L.) O. Ktze.
7. *Launaea nudicaulis* HK. f. (non-Less.)
8. *Aerva javanica* (Burm.F.) Juss.
9. *Suaeda fruitcosa* (L.) Pers.
10. *Chloris barbata* Sw.
11. *Cynodon dactylon* (L.) Pers.
12. *Eclipta prostrata* (L.) L.
13. *Cenchrus ciliaris* L.
14. *Cressa cretica* L.
15. *Digera muricata* (L.) Mart.
16. *Eragrostis ciliaris* (L.) R. Br.
17. *Amaranthus virids* L.
18. *Tephrosia uniflora* Pers.
19. *Schweifurthia papilionacea* (Burm.f.) Boiss.

DISCUSSION

Effluents from towns and cities are the main source of damage to river plants from pollution. Vegetation is a good indicator of the quality of the soil which affects it in every conceivable direction. Thus for a natural vegetation of a particular climatic area, the relationship of plant to soil is very close (Keyani *et al.* 1981). Six plant communities were found on the heap area, whereas five communities were recorded on the plain area. Nineteen species were reported on the heap area as compared to only seven species on the plain area. Reduction in number of species was noted in all the waste disposal drains investigated along the plain area as compared to the heap area due to sewage pollutant. Plant density, species richness and diversity all decreased with increasing in sludge rate on a degraded semi-arid broom snake weed (Frequez *et al.* 1990).

The presence of *P. geminatum* as a pure population on both heap and plain areas suggested that this monocotyledenous species is more tolerant to the polluted conditions of the waste disposal drains. The tolerance of *P. geminatum* to sewage pollutant is also noted by Iqbal and Qadir (1974) around the polluted industrial waste channels. In physiological mechanism of pollution injury, many factors such as light, wind, water, temperature and mineral nutrient affect the responses of plants to pollutant (Roberts 1954; Besch and Roberts - Pichette 1970). During the past decade, the use of sewage sludge and sludge composts on crop lands has increased, and concern has mounted for the heavy metals, which are entering in the food chain in concentration harmful to both plants and animals. Deficiencies of some elements and the toxic effects of others severely limit yield (Greenwood, 1982). Many metals such as Fe, Zn, Pb, Cd, and Cu may enter river in effluents, from industries and domestic purposes. The soil characteristics along water channels showed a significant correlation with vegetation type. *P. geminatum* had a wide ecological amplitude and was found as a first dominant in different stand with a wide range of soil pH. At the lowest pH level (6.4) it was found as a pure population on the plain area, whereas at pH 6.6 it was found on the heap area as a pure population. *A. lagopoides* changed its association and preferred to grow with *P. juliflora*. A high pH which caused a significant effect on the vegetation pattern, was also recorded by Iqbal and Qadir (1974) in most of the stands around the polluted industrial waste channels. However, Fresquez *et al.* (1991) found that after four years the soil pH decreased from 7.8 in the control to 7.0 in the sludge-amended treatment applied at the highest rate (90 Mg ha_{-1}) (Freszuez *et al.* 1990b) and concluded that normally heavy metal's solubility increases as soil pH decreases to 7.0 (Bohn *et al.* 1979), therefore, the decrease in soil pH from 7.8 to 7.0 established a potential for solublization of heavy metals and the subsequent uptake of these elements by plants.

The percentage of organic matter and calcium carbonate was found low in the plain area as compared to the heap area. The type and quantity of organic matter in soil have very large influences on the structure of the soil and hence the ability of fine feeding roots to penetrate in search of nutrient. Nutrient availability is one of the prime factors determining the plant distribution and productivity (Chapin, 1982).

The decrease in the soil organic matter percentage might be the cause of reduction in number of species on the plain area. As the concentration of organic matter increases, the deep rooted species *P. juliflora* appeared on the heap area and made the area floristically rich. Studies of nutrient cycling on the Rio Puerco, have shown that many of these soils are extremely low in organic matter and plant available nitrogen (Fresquez *et al.* 1988; Aldon *et al.* 1988; Whiteford *et al.* 1989). Stabilized sewage sludge has potential for amending degraded calcareous grassland soils by replenishing organic matter and acting as low grade slow-release fertilizer (Mc Caslin and O'Conner, 1982). As an organic amendment, dried sewage sludge can be expected to increase soil cation exchange capacity while improving soil aggregation and tilth (Erikson 1973). Calcium carbonate is widely distributed in soil occurring separately or associated with other salts. On the heaps the better calcium carbonate concentration made the biological activity high, which made the soil fertile. A variation in calcium carbonate concentration had also shown a significant relationships with vegetation types. *P. geminatum* formed a pure population at the highest concentration of $CaCO_3$ on the heap area, however, at lower level it formed an association with *C. ciliaris.*

The amount of exchangeable sodium and potassium on both areas was found in appreciable concentration, as in arid area, where precipitation is insufficient to leach out the soluble sodium salts. Various concentration of sewage effluents channels had a marked influence on vegetation. At lowest concentration (16.3 ppm) of Na^+, *S. surrattense* formed a pure population on the heap area. *P. geminatum* formed a pure population with higher exchangeable sodium concentration on both areas, which might be the cause of the highest occurrence in a number of stands on both areas.

Availability of soil potassium is influenced by both soil and plant factors (Jungk *et al.* 1982). Since potassium concentration of the soil solution is low, potassium transports from the soil to the plant root proceeds mainly by diffusion (Barber, 1962). A high concentration of potassium was found in the *Limenium-Cyperus* community on the plain area. At low concentration of potassium, *C. laevigatus* stood first dominant and *L. indicum* became second dominant, which indicated that *L. indicum* was more tolerant to increase in potassium concentration as compared with *C. laegivatus*. A wide range of K^+ concentration (100 - 800 ppm) suggests that K^+ ions are mobile. Many results have indicated that photosynthesis activity is relatively insensitive to potassium supply (Ozbun *et al.* 1965b). However, photosynthesis was rapidly altered upon the changing of the supply of potassium to unicellular algae (Overwell, 1975) and also to higher plants such as maize (Peaslee and Moss, 1966) and sugar beet (Terry and Ulrich, 1973).

The trace elements have specific functions and all of them are known to be involved in enzyme action. They can adversely affect plant growth (Kena and Supstan, 1972). Human activities are also the primary source of such elements such as lead, zinc, and copper. Plants under stress condition are most likely to be adversely affected by high concentration of heavy metals than the nutritionally healthy ones, even though the metal uptake is the same (Channey *et al.* 1977). Among other micro nutrients, the availability of copper also influences vegetation distribution. The value above 150 ppm for total copper had been considered as toxic. In our investigations it was found in the range of 200 to 640 ppm on both areas which is above the permissible toxic level. A correlation was found between vegetation types. *C. laevigatus* was in association with *L. indicum* at low organic matter content and low copper content. As soon as the concentration of organic matter increases, the *L. indicum* becomes first dominant along with *C. laevigatus*. But on the other hand, it is not true with *A. lagopoides* species. *A. lagopoides* in association with *P. juliflora* preferred to grow at high organic matter and low copper contents. While *A. lagopoides* in association with *C. barbata* preferred to grow at low organic matter content and high copper concentration. This trend of adaptation might be due to the mineral requirement of the different species. It depends on a certain level of the essential elements existing in the plant. If a concentration is less or great than optimum, stress may occur resulting in the appearance of visual symptoms and reduced yield. Plant may go through periods of stress caused by less than optimum elemental levels in tissue (Jones, 1982). Another important micro nutrient element is zinc which in the soil generally falls with the range of 10 - 300 ppm. Total Zn^{++} levels of above 150 ppm in soils can be regarded as high and levels of 40-150 ppm as medium. In our investigation, total zinc level on the plain area reached to toxic level as compared with heap area. While *P. geminatum* at its ever highest concentration formed a pure population on the plain area. The level of heavy metals such as lead was found more or less in the same range (10-35 ppm) on both plain and heap areas. *L. indicum* and *C. laevigatus* was found at the highest concentration (30 ppm) on the plain area, which indicates its tolerance to lead concentration.

It is concluded that vegetation close to sewage effluents channels is adversely affected by sewage pollutant. The bare areas were regularly observed almost in every stand during the study, which could be attributed to disturbance by man together with disposal of pollutant and grazing in the area. Over flowing and seepage of polluted water must be checked. Cementing, covering of polluted channels and depth of the Lyari river should be increased. Animal and human waste must be recycled and could be utilized as a fertilizer. Plant material and soil analysis should be carried out periodically to monitor the toxic levels of pollutant. Improving water quality by dilution would be helpful in reducing toxic effect.

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巴基斯坦里亞力河污水渠道邊的植物社會

M. Zafar Iqbal[1], Damian Gill[1] and Muhammad Shafiq[1, 2]

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摘　　要

里亞力河沿岸植被的優勢種多為單子葉植物，如 *Paspalidium geminatum* (類產稗)、*Cyperus lavigatus* (平滑莎草)、Chloris barbata (孟仁草) 及 *Aeluropus lagopoides* (獐茅)。在泥堆上計發現 6 種植物社會及 19 種植物，而在平坦地區有 7 種植物，形成 5 種植物社會。*P. geminatum* 在兩區均佔絕對優勢，凸顯出該種對污水的高容忍性。兩類地區的土壤特性 (pH、$CaCO_3$、有機質、Na^+、K^+、Pb^{++}、Zn^{++} 及 Cu^{++})均與植被類型呈相關。泥堆之土壤 pH、可交換性鈉、鉀、鋅及銅均高於平坦地，$CaCO_3$ 及有機質則相反，但是鉛之含量則相同。銅之有效性在兩區均隨著土壤之 pH 增高而上升，同時其濃度為 200～640 ppm，均高於最低毒害濃度（150 ppm）。鋅之濃度則降低到有毒標準以下，而且未超過 300 ppm。

關鍵字：重金屬、植物社會、河川、污水、排放、土壤特性。

1.巴基斯坦喀拉蚩大學植物系。
2.通信聯絡員。