

## Water Quality and Biodiversity of Manka Canal (D.G. Khan), Pakistan

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**Abstract:** A study was carried out to measure the physico-chemical and biological parameters of Manka Canal water at D.G. Khan, Pakistan. Water samples were collected and analyzed on monthly basis for a period of ten months. Different measured parameters were light penetration (7.2 to 12.8 cm); pH (6.81 to 8.26); electrical conductivity (0.23 to 1.5 dS m<sup>-1</sup>); turbidity (0.325 to 1.589 mg l<sup>-1</sup>); viscosity (0.735 to 0.976 mN S m<sup>-2</sup>); surface tension (77.39 to 101.1 dynes cm<sup>-1</sup>); dissolved O<sub>2</sub> (3.9 to 6.1 mg l<sup>-1</sup>); free CO<sub>2</sub> (5.9 to 11.4 mg l<sup>-1</sup>); alkalinity (16.4 to 78.8 mg l<sup>-1</sup>); total hardness (190 to 671 mg l<sup>-1</sup> as CaCO<sub>3</sub>); total solids (0.11 to 1.72 mg l<sup>-1</sup>) and total volatile solids (0.01 to 0.18 mg l<sup>-1</sup>); SAR (0.39 to 2.04) and RSC (0.00 to 1.18 meq l<sup>-1</sup>). An attempt was also made to assess the seasonal fluctuation in biological parameters. Phytoplankton were abundant as compared to Zooplankton. Sixty four Phytoplankton genera were recorded including 9 of Cyanophyta, 30 of Chlorophyta, 16 of Chrysophyta, 2 of Cryptophyta, 4 of Euglenophyta and 3 genera of Pyrrophyta. Seventeen genera of Zooplankton were observed including 10 of Protozoan, 5 of Rotifers and 2 of Cladocerans. Diversity index of Phytoplankton ranged from 2.73 to 3.72 and diversity index of Zooplankton ranged from 0.48 to 1.44. It may be concluded that the quality of canal water is marginally fit as the diversity indices of Phyto- and Zooplankton was less than three in most of the study period.

**Key words:** Water pollution • Relative abundance • Phytoplankton • Zooplankton • Diversity index

### INTRODUCTION

Today, many rivers of the world receive millions of liters of sewage, domestic waste, industrial and agricultural effluents [1]. Shrinking water resources are creating mess of socio-economic problems for the developing countries. Pakistan is one of those countries whose demand of water for agricultural, industrial and domestic use is being anticipated to climb up and outstrip the sustainable supply that would put the country in chronic and severe water crisis. At present the per capita availability of water is 1100 m<sup>3</sup> which is anticipated to drop to 837 m<sup>3</sup> in 2025. An indiscriminate and unchecked disposal of untreated municipal and industrial wastes into the water bodies is resulting in deterioration of quality of both ground and surface waters [2].

Less than half the urban sewage is drained off through sewers and covered drains and only a small fraction of that is treated before being disposed off into water bodies [3]. Use of poor quality contaminated waters

would have devastating effects on human health, agricultural production and the environment quality. The main danger can come from salts, toxic ions, faecal pathogens and heavy metals. Salts and toxic ions when accumulate in the agricultural soils lead to the soil degradation and decrease in crop yield while pathogens and heavy metals cause the serious diseases in human and livestock. So, price of failure to protect the quality and purity of the groundwater, lakes and river waters would be very high [4].

Water quality includes all physical, chemical and biological characteristics of water [5]. Biological characteristics are related to density and diversity of organisms [6]. Freshwater ecosystems have lost a greater proportion of their species and they face increasing threats from dams, over extraction, pollution and over fishing [7].

Biodiversity is an important indicator of human interference with a natural ecosystem which often leads to reduce diversity. Relatively fewer numbers of species are

found in polluted water than clear water. Diversity in a given area over a period of time can be a fair measurement of the effects of pollution [8]. The quantity and quality of Phytoplankton is a good indicator of water quality. The high relative abundance of Chlorophyta indicates productive water [1]. Zooplankton are an intermediate step in aquatic bio-loop and an ecosystem [9].

D.G. Khan is located on the western side of Indus River and its area is categorized as Barani, in general, because the western side of the city receives hill torrents of Sulaiman Range. The groundwater is saline. The only potable water is from the seepage of Manka and D.G. Khan Canals. The estimated pollution load in Manka Canal is 60 Cusecs [10]. It is essential to monitor the water quality continuously to determine the level of pollution. This information can be shared with general public and government to develop policies for the conservation of freshwater resources [11].

Keeping in view the importance of freshwater resources, the present study was conducted to investigate the water quality and biodiversity of Manka Canal at D.G. Khan, Pakistan.

## MATERIALS AND METHODS

The present study was carried out on mixed water (sewage + Manka Canal water) at D.G. Khan, Pakistan (*longitude* 70°29' 7" E and *latitude* 29°57' 38" N). The study site was suitable for limnological studies as the depth and flow of water was maximum. Water samples from the surface water column ( $\leq 1$  m depth) were collected in plastic bottles of 1.5 liter capacity on monthly basis for a period of ten months. The bottles were labeled date, time and name of sample with the help of water proof marker.

At the time of sampling, the air and water temperatures were recorded by using alcoholic thermometer. Light penetration was recorded with the help of Sacchi's disc. Boiling point was measured by using mercury thermometer. Electrical conductivity and pH were measured by using conductivity meter (AGB-1001, Japan) and pH meter (HI-8417). Density, specific gravity, viscosity and surface tension were determined by standard methods [12]. While all other parameters including turbidity, dissolved O<sub>2</sub>, free CO<sub>2</sub>, alkalinity, acidity, total hardness, total solids (TS), total volatile solids (TVS), total dissolved solids (TDS), total volatile dissolved solids (TVDS), sodium adsorption ratio (SAR) and residual sodium carbonates (RSC) were determined by the methods as described by Boyd and Tucker [1].

The water samples for plankton study were preserved by using 4% formalin solution [13] and examined under a microscope using 10x ocular and 10x and 40x objectives. The identification of Phytoplankton and Zooplankton was done up to generic level with the help of literature [13-16]. Frequency of occurrence (%) and relative abundance (%) of each genus of Phytoplankton and Zooplankton was calculated for each month. Diversity index of plankton was calculated by using following formula as described by Boyd [5]:

$$\text{Diversity Index (H')} = \frac{S-1}{\ln S}$$

Where:

S = The number of genera of Phyto- or Zooplankton

N = The total number of Phyto- or Zooplankton

ln = Natural logarithm

## RESULTS AND DISCUSSION

**Physical Parameters:** The overall range in air temperature observed was 25 to 41.5°C while water temperature was minimum (19°C) in December and maximum (32.5°C) in July. Air and water temperature showed an increasing trend reaching peak in July and gradually declined confirming the usual phenomena found in most studies. The maximum light penetration (12.8 cm) was observed in June and minimum (7.2 cm) in December. Light and temperature are exogenous factors which are called as driving variables while nutrient concentration is linked dynamically with growth [17]. The boiling point was maximum (99.1°C) in March and minimum (96.2°C) in September. The maximum water density (1.096 gm l<sup>-1</sup>) and specific gravity (1.099) was found in September.

The turbidity was maximum (1.589 mg l<sup>-1</sup>) in March and minimum (0.325 mg l<sup>-1</sup>) in October. Higher turbidity reduces the amount of light penetrating the water which ultimately reduces photosynthesis and the production of dissolved oxygen by aquatic plants [1, 18]. The viscosity (0.976 mN S m<sup>-2</sup>) was observed maximum in June and minimum (0.735 mN S m<sup>-2</sup>) in March. Surface tension ranged from 77.39 to 101.1 dynes cm<sup>-1</sup> (Table 1). Surface tension of water varies with temperature and with the content of dissolved solids [19].

**Chemical Parameters:** The monthly variation in pH ranged from 6.81 (March) to 8.26 (June) due to seasonal variation in flow of water and contamination by domestic sewage. pH is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity [20].

Table 1: Monthly variations in physical parameters of Manka Canal water

Parameters	Months									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air temperature (°C)	30.0	39.0	40.0	41.5	38.5	36.9	35.0	34.0	28.0	25.0
Water temperature (°C)	28.0	29.0	30.0	32.5	32.0	31.0	30.0	24.5	20.5	19.0
Light penetration (cm)	7.2	10.3	10.0	12.8	11.5	10.9	9.2	10.5	8.5	7.6
Boiling point (°C)	99.1	98.0	97.6	97.3	97.3	98.0	96.2	96.4	97.0	97.5
Density (gm l <sup>-1</sup> )	0.994	1.040	1.032	1.028	1.036	1.032	1.096	1.004	1.029	1.032
Specific gravity	1.011	1.043	1.035	1.031	1.039	1.035	1.099	1.017	1.031	1.035
Turbidity (mg l <sup>-1</sup> )	0.425	0.669	0.799	1.589	0.657	0.605	0.463	0.393	0.364	0.325
Viscosity (mN S m <sup>-2</sup> )	0.735	0.747	0.815	0.976	0.868	0.889	0.932	0.854	0.912	0.975
Surface tension (dy. cm <sup>-1</sup> )	94.96	93.81	95.11	96.79	95.48	99.43	101.1	77.39	88.94	93.08

Table 2: Monthly variations in chemical parameters of Manka Canal water

Parameters	Months									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pH	8.26	7.62	7.60	6.81	7.80	7.50	7.67	7.55	7.60	7.80
EC (dS m <sup>-1</sup> )	1.50	0.74	0.25	0.35	0.23	0.60	0.50	0.54	0.37	0.50
Dissolved O <sub>2</sub> (mg l <sup>-1</sup> )	4.3	4.8	5.7	4.8	5.0	4.2	3.9	4.9	5.3	6.1
Free CO <sub>2</sub> (mg l <sup>-1</sup> )	5.90	9.96	9.21	11.4	9.93	7.89	8.21	10.9	8.81	10.9
Acidity (mg l <sup>-1</sup> )	41	47	47	92	102	53	42	61	86	91
Hardness (mg l <sup>-1</sup> )	671	270	254	270	222	360	300	240	190	210
Alkalinity (mg l <sup>-1</sup> )	78.8	32.0	18.2	26.9	16.4	32.0	26.5	29.2	18.0	29.0
TS (mg l <sup>-1</sup> )	0.11	0.61	0.59	1.58	0.60	0.71	0.58	0.37	0.33	1.72
TVS (mg l <sup>-1</sup> )	0.01	0.02	0.18	0.08	0.05	0.16	0.07	0.07	0.10	0.03
TDS (mg l <sup>-1</sup> )	0.44	0.29	0.23	0.31	0.16	0.49	0.54	0.44	0.36	1.42
TVDS (mg l <sup>-1</sup> )	0.04	0.03	0.06	0.13	0.11	0.13	0.16	0.12	0.16	0.44
SAR	2.04	0.71	0.39	0.44	0.43	1.36	0.86	0.48	0.85	0.84
RSC (meq l <sup>-1</sup> )	1.18	0.5	Nil	0.18	0.58	Nil	Nil	0.52	Nil	0.80

The pH of water in different months was within the WHO limits i.e. 6.5-8.5. Low pH interferes with oxygen uptake and reducing activity or feeding [21]. The maximum conductivity (1.5 dS m<sup>-1</sup>) was observed in March and minimum (0.23 dS m<sup>-1</sup>) in July. The fluctuations in EC are due to fluctuation in total dissolved solids and salinity [5]. The maximum dissolved oxygen (6.1 mg l<sup>-1</sup>) was observed in December and minimum (3.9 mg l<sup>-1</sup>) in September. Dissolved oxygen showed inverse significant correlation with free CO<sub>2</sub>. Dissolved oxygen is very crucial for survival of aquatic organisms and it is also used to evaluate the degree of freshness of river [22]. The maximum free CO<sub>2</sub> (11.4 mg l<sup>-1</sup>) was observed in June and minimum (5.9 mg l<sup>-1</sup>) in March. The maximum value of acidity (102 mg l<sup>-1</sup>) was observed in July and minimum value (41 mg l<sup>-1</sup>) in March. In natural unpolluted waters, the acidity is mainly contributed by dissolve CO<sub>2</sub> through the acids produced by the reaction of carbon dioxide and water. In polluted waters, weak acids like acetic acid may contribute significantly to total

acidity. In some industrial wastes, organic acids may also contribute to acidity [23]. The maximum hardness (671 mg l<sup>-1</sup>) was observed in March and minimum (190mg l<sup>-1</sup>) in November (Table 2). Hardness levels above 500 mg l<sup>-1</sup> are generally considered to be aesthetically unacceptable [24].

The maximum alkalinity (78.8 mg l<sup>-1</sup>) was observed in March and minimum (16.4 mg l<sup>-1</sup>) in July. The maximum value of TS (1.72 mg l<sup>-1</sup>) was observed in December and minimum (0.11 mg l<sup>-1</sup>) in March. Similarly, the maximum TVS (0.18 mg l<sup>-1</sup>) were maximum in May while minimum (0.01 mg l<sup>-1</sup>) in March. The maximum TDS (1.42 mg l<sup>-1</sup>) and TVDS (0.44 mg l<sup>-1</sup>) were observed in December and minimum (0.54 mg l<sup>-1</sup>) in July and (0.03 mg l<sup>-1</sup>) in April, respectively. Although, the elevated levels of total dissolved solids are not considered as a human health risk, yet these can affect the taste and odour of drinking water and overall quality of the water and soil [25]. The SAR fluctuated from 0.39 to 2.04 and RSC was maximum (1.18 meq l<sup>-1</sup>) in March (Table 2).

Table 3: Distribution (%) of different phyla in Manka Canal water

Name of Phyla	Months									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cyanophyta	4.50	1.03	8.16	2.34	11.11	6.61	2.86	3.88	-	4.45
Chlorophyta	40.45	42.27	31.64	52.34	33.34	31.40	55.24	48.56	46.0	47.78
Chrysophyta	44.94	28.86	46.94	28.92	23.45	45.45	20.95	35.92	25.0	36.67
Cryptophyta	-	5.18	8.16	-	-	-	5.71	-	9.0	1.11
Euglenophyta	1.12	-	-	6.25	-	0.83	2.86	-	-	-
Pyrrhophyta	-	6.18	-	-	11.11	3.30	4.76	-	-	3.33
Protozoa	2.25	6.18	4.08	10.15	11.11	4.97	7.62	5.82	18.0	6.66
Rotifera	-	10.30	1.02	-	9.88	6.61	-	5.82	2.0	-
Cladocera	6.74	-	-	-	-	0.83	-	-	-	-

Table 4: Relative abundance (%) of Phyto- and Zooplankton in Manka Canal water

Parameters	Months									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of Phytoplankton	126	73	171	129	83	196	281	398	120	161
No. of Zooplankton	05	15	08	9	10	20	7	21	07	01
Total No. of organisms	131	88	179	138	93	216	288	419	127	162
R.A. of Phytoplankton	96.2	82.9	95.5	93.5	89.3	90.7	97.6	95.0	94.5	99.3
R.A. of Zooplankton	3.8	17.1	4.5	6.5	10.7	9.3	2.4	5.0	5.5	0.7

**Biological Parameters:** Total 81 genera were observed in which 64 were of Phytoplankton and 17 of Zooplankton. Phytoplankton belong to Cyanophyta (9 genera), Chlorophyta (30 genera), Chrysophyta (16 genera), Cryptophyta (2 genera), Euglenophyta (4 genera) and Pyrrhophyta (3 genera) while Zooplankton included Protozoan (10 genera), Rotifers (5 genera) and Cladoceran (2 genera).

Among the Phytoplankton, the members of Chlorophyta and Chrysophyta were present throughout the study period. The members of Cyanophyta were present in all months except November. Lowest frequency of occurrence was found in Euglenophyta as they were present only in four months. Among the Zooplankton, Protozoan were present in all months. Rotifers were present in all months except March, June, September and December while Cladoceran were present only in March and August (Table 3).

Chrysophyta was maximum in May and minimum in September which gradually decreased showing direct relation with seasonal changes. Chrysophyta showed inverse relation with Chlorophyta. Similar relation between Cyanophyta and Chlorophyta was observed by Shepherd and Bromage [26]. Over abundance of Phytoplankton causes an imbalance in dissolved oxygen that may cause daily net deficit in dissolved oxygen availability. Some blue green algae are poor oxygenators

because much of the oxygen produced by Phytoplankton in surface scum is lost to the atmosphere rather than dissolved in the water [1].

Phytoplankton were most abundant as compared to Zooplankton during the whole study period. Total number of organisms was observed 1012, out of which 892 were Phytoplankton with relative abundance of 88.1% and 120 were Zooplankton with relative abundance of 11.9%. Chlorophyta and Chrysophyta were most abundant Phyla. The relative abundance (R.A) of Phyto- and Zooplankton is given in Table 4.

In March, among Phytoplankton, *Navicula* (Chrysophyta) was the most abundant genus with R.A 16.9% while in Zooplankton, *Daphnia* (Cladocera) was the most abundant genus with R.A 6.74%. In April, among Phytoplankton, *Chlorella* (Chlorophyta) was the most abundant genus with R.A 13.4% while in Zooplankton, *Ascomorpha* (Rotifer) was the most abundant genus with R.A 5.15%. In May, among Phytoplankton, *Navicula* (Chrysophyta) was the most abundant with R.A 12.2% while in Zooplankton, *Hemiphrys* (Protozoan) was the most abundant genus with R.A 3.1%. In June, among Phytoplankton, *Chlorella* (Chlorophyta) was the most abundant genus with R.A 10.9% while in Zooplankton, *Hemiphrys* (Protozoan) was the most abundant genus with R.A 5.5%. In July, among Phytoplankton, *Cyclotella* (Chrysophyta) was the most abundant genus with

Table 5: Diversity indices of Phyto- and Zooplankton in Manka Canal water

Months	Phytoplankton				Zooplankton			
	*S	*N	*ln N	Diversity Index	*S	*N	*ln N	Diversity Index
Mar	13	81	4.39	2.73	2	8	2.08	0.48
Apr	13	81	4.39	2.73	5	16	2.77	1.44
May	15	93	4.53	3.09	3	5	1.60	1.25
Jun	17	115	4.74	3.37	2	13	2.56	0.39
Jul	13	64	4.16	2.88	3	17	2.83	0.71
Aug	16	106	4.66	3.22	4	15	2.70	1.11
Sep	18	97	4.57	3.72	2	8	2.08	0.48
Oct	15	91	4.51	3.10	3	12	2.48	0.81
Nov	16	80	4.38	3.42	4	20	2.99	1.00
Dec	15	84	4.43	3.16	2	8	2.08	0.48

\*S = No. of Genera, N = Total Organisms, ln = Natural logarithm

R.A 12.3% while in Zooplankton, *Colurella* (Rotifer) was most abundant genus with R.A 9.9%. In August, among Phytoplankton, *Cocconeis* (Chrysophyta) was the most abundant genus with R.A 12.4% while in Zooplankton, *Psuedodifflugia* (Protozoan) was the most abundant genus with R.A 4.9%. In September, among Phytoplankton, *Cosmarium* (Chlorophyta) was the most abundant genus with R.A 9.5% while in Zooplankton, *Arcella* (Protozoan) was the most abundant genus with R.A 4.8%. In October, among Phytoplankton, *Oocystis* (Chlorophyta) was the most abundant with R.A 16.5% while in Zooplankton, *Colurella* (Rotifer) was the most abundant genus with R.A 5.8%. In November, among Phytoplankton, *Closterium* (Chlorophyta) was the most abundant genus with R.A 12.5% while in Zooplankton, *Cyphoderia* (Protozoan) was the most abundant genus with R.A 8.0%. In December, among Phytoplankton, *Chlorella* (Chlorophyta) was the most abundant genus with R.A 11.1% while in Zooplankton, *Arcella* (Protozoan) was the most abundant genus with R.A 6.7%.

Diversity index of Phytoplankton was found to be highest in September (3.72) and lowest in March and April (2.73), showed an increasing trend up to September and then decreased in rest of months. Diversity index of Zooplankton fluctuated from 0.48 to 1.44, by showing decreasing trend up to July and again increasing in August then decreasing from September to October (Table 5).

Plankton increased their abundance during summer, probably corresponding to the water quality, decaying vegetation, increased levels of organic matter in the sediment and higher abundance of bacteria during this time [27]. In contrast, their abundance decreased in winter, probably corresponding to low water temperature and high alkalinity (pH 7.6-9.8) of water [28]. Diversity indices

are good indicator of pollution in aquatic ecosystem. Diversity index value greater than 3 indicates clean water. Values in the range of 1 to 3 are characteristics of moderately polluted conditions and values less than 1 characterize heavily polluted condition [29].

## CONCLUSION

Most of the monitored parameters of Manka Canal water fall within the permissible limits for irrigation use. However, diversity indices of biota, observed values <3 during the most of the study period, indicates that canal water is moderately polluted. The main source of pollution is domestic sewage water that should be properly treated before disposal to save the freshwater resources. Although heavy metals may not be a problem as no industries are present in this area at this stage, yet this aspect needs consideration in further studies.

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