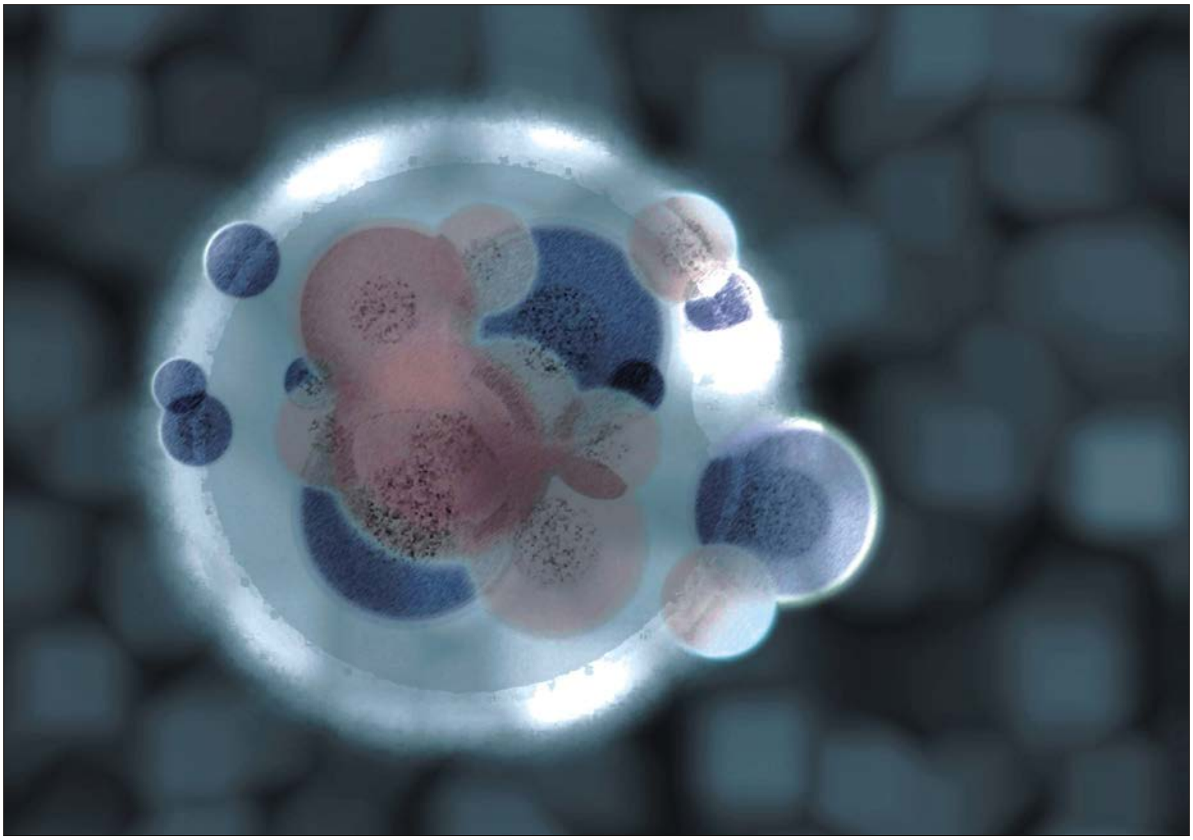

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Pollutant Monitoring of a Drainage Canal Receiving Industrial and Agricultural Wastewater Incukurova Plain

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Abstract: The TD-7 drainage channel has been exposed to wastewater discharges of different characteristics from multiple sources, due to industrial establishments and dense settlement in the vicinity. In this study, seasonal changes of the characterization of the water carried by the channel, which is also used for agricultural irrigation purposes, was examined for biological, physical and chemical characteristics in water samples, taken from five selected observation points along the channel. The observation points were decided, so as to demonstrate characteristic changes in water and sludge quality, reflecting the effects of wastewater discharge points and hydraulic profile. According to the result of monthly analyses performed on water of the drainage channel, maximum and minimum values of quality and pollution parameters were; suspended solids (SS), 30-210 mg L^{-1}; electrical conductivity (EC), 734-1937 µS; 5-day biochemical oxygen demand (BOD_5), 97-305 mg L^{-1}; chemical oxygen demand (COD), 174-429 mg L^{-1}; total coliform, 250- >1100 EMS mL^{-1}. Accumulations in the sediments were also observed for some heavy metals (Pb, Cd, Ni, Cu, Mn, Zn, Fe), sampled from the same observation points. The sets of analysis demonstrated that, with the present wastewater discharges the water drawn from the TD-7 drainage channel cannot be used for agricultural purposes according to existing regulations.

Key words: Drainage channel, heavy metal pollution, sediment, water characterization

INTRODUCTION

Concerns over agricultural and industrial water pollution sources in integrated water quality management have been growing recently. Pollution sources are likely to be even more critical in developing countries, where agricultural land and rural populations are intensive, having significance because of instream water use in irrigation, waste disposal and daily purposes. Also weak enforcement capacity of the regulations for the situation increases complexity of the problem. Lower Seyhan Plain is a typical sample for the case.

In Lower Seyhan Plain irrigation is necessary for agricultural production. The climatic conditions are hot and dry in the summer and warm and rainy in the winter with high humidity throughout the year. The farmers have to irrigate the land continuously, even more then before, as continual crop rotation becomes more and more widespread. This continual irrigation process produces problems in farm water management which then creates the risk of soil pollution. This threatens the crop productivity in the high quality plains and necessitates control and management of soil pollution and public health regulations (Odeh, 1998; Kelleners and Chaudhry, 1998; Kotb *et al*., 2000). On this land, the drainage canal network consists of 2 main canals, both of which are secondary and tertiary drainage canals. The total length of the secondary and tertiary drainage canals is approximately 1,373 km (Tekinel and Yazar, 1984) Drainage canals are known to be under the threat of pollution by contaminants from industrial and agricultural wastewater in the Lower Seyhan Plain. This is due to 15% of all industrial operations in Turkey being located in this area and 35% of Turkey's agricultural activities occurring in this area, both. The drainage canals carry industrial, domestic and agricultural wastewater. But municipal wastewater also contains inorganic substances from domestic, agricultural and industrial sources including a number of potentially toxic elements such as heavy metal (Younas *et al*., 1998).

This study examines tertiary drainage canals called TD7 in industrial and farm lands and ascertains the changes of the pollutants in the water carried by the canals and sediments throughout the year 2003.

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MATERIALS AND METHODS

Study site: This study was carried out in a tertiary drainage canal in the Lower Seyhan Plain Irrigation Project Area in Turkey The study area lies between 36°30' and 37°00' northern latitude and covers a 12,000 ha of irrigated lands. The Seyhan River divides the area into two plains which are the Yuregir and Seyhan. These both have typical Mediterranean climate and their soils can be grouped into five geomorphic units (Dinc *et al*., 1990). A wide range of crops can be grown in this area of rich, deep alluvial soils with smooth topography and temperate climate. However, serious drainage and salinity problems have arisen due to excess irrigation water application and management issues at both the system and farm level since the irrigation project began in the 1960's (Cetin and Ozcan, 1999), Even though high quality irrigation water (EC of 0.4 dS m^{-1}) was available, seepage and leaching of the salts from the up-stream irrigated areas caused drainage and soil salinity problems in the lower areas of ASO, covering 45,845 ha. A development project, called Fourth Stage Project (FSPA), is underway to reclaim these areas. The study area in this project is inside this FSPA, which presently lacks water irrigation and drainage systems and is positioned between the Mediterranean Sea and a currently irrigated area. Because it has an extremely flat topography and an altitude of less than 5 m above mean sea level, pumping is essential for discharging the drainage water. The main drainage canals carry left over irrigation water from upstream irrigated land and the city untreated domestic drainage water which cuts across the FSPA.

The farmers of this area have no access to good quality water and continue to divert irrigation water from the drainage canals with the EC being over 1.5 dS m^{-1}. It is of interest to note that cotton, corn and wheat are among the major crops grown in the FSPA.

The cotton seed yield of 4.0-5.2 t ha^{-1} fluctuates according to the level of quality of the irrigation water used. When high quality irrigation water is used, the yields are comparable with the yields of the highland areas. But during the irrigation seasons, farmers frequently block the drainage canals to irrigate their cotton fields with furrow irrigation. Due to the drainage canals being unlined, the blockage causes seepage into surrounding fields particularly during July and August. This decreases the subsequent crop yield and lowers the level of the soil quality affecting future crops.

Sampling and analysis: This study was specifically conducted on the TD7 drainage canal which is part of the FSPA. TD7 has a total length of 15,250 meters. Five sampling points were positioned according to different sources of pollutants along TD7. The selection criteria for station locations are given in Table 1.

Table 1: Station selection criteria

St.	Location (km along TD7)	Reasons of determination
1	0	Initial point. Characterization of water and sediments originated from upstream
2	2	Water quality change. Discharge of industrial wastewater
3	4	Water quality change. Discharge of textile wastewater 4
	12	Probable water quality change. Concentrated agricultural activities.
5	15	End of TD7. The pollutant carried by TD7 to TD0

Sampling of water and sediments was carried out simultaneously. The water samples were analyzed for electric conductivity (EC), pH, total suspended solids (TSS), chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD_5), total coliform (TC), total aerobic mesofilic bacteria (TAMB) and *E. coli*. pH and temperature were measured on site, using digital equipment. Also, salinity was measured using a salinometer, on site. The water samples were collected in PVC containers, stored, transported to the laboratory and analyzed for remaining parameters, according to the corresponding Standard Methods.

Sediment samples were also collected at the five sampling points, using an Ekman Grab Sampler, consisting of a stainless steel cabinet to which two sprung jaws are attached. Every sample consisted of nearly 350 g of sediment. Canal bottom sediments have a sharp smell and a dark brown/black appearance. The samples were transported to the laboratory and stored in glassware. These samples were analyzed using the US EPA Method 3050B hotplate digestion technique to digest and analyze for Cu, Pb, Zn, Cd, Ni, Fe and Mn. Trace metals content of the sample solutions were analyzed using Perkin Elmer FLAA.

RESULTS AND DISCUSSION

Water quality: During the study, conducted through about a year, the water quality indicators of physical, chemical and microbiological parameters, including pH, EC, TSS, COD, BOD_5, TC, *E. coli* and total aerobic mesofilic bacteria, were observed.

As it can be seen in Table 2 and 3 that, all the pollution parameters show an increase at the stations 2 through 4. This is due to presence of two industrial wastewater discharges into the canal at the downstream of stations 1 and 3. Besides these two industrial point discharges, there exists only agricultural and a few domestic wastewater discharge, after the second point discharge. It should be noted that, upstream of the first

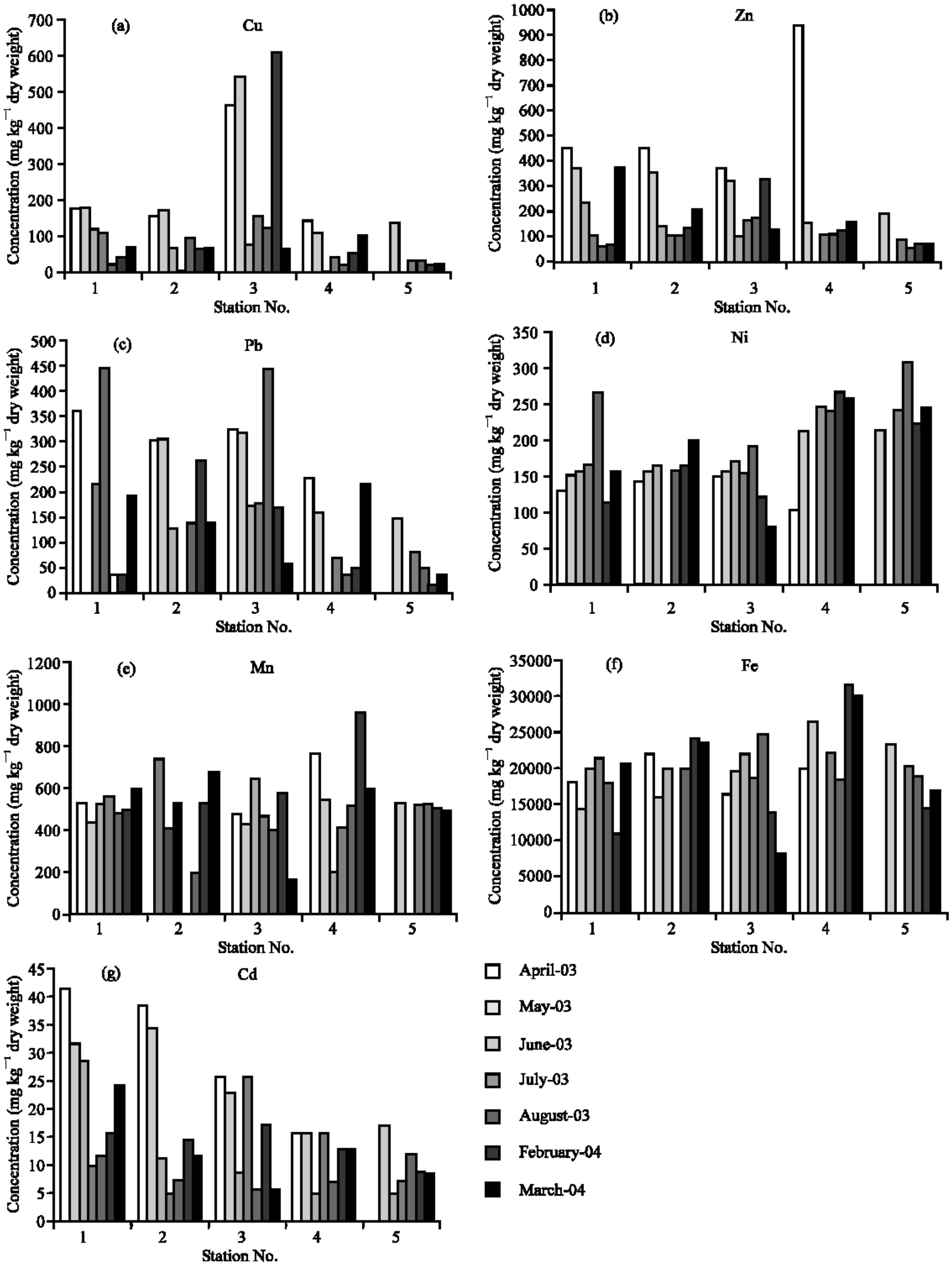

Fig. 1: Deviation of (a) Cu, (b) Zu, (c) Pb, (d) Ni, (e) Mn, (f) Fe and (g) Cd concentrations through the 5 sampling stations for seven months

station also has industrial, domestic and agricultural wastewater discharges. The effects of the location of these discharges can be seen from the quality of the water carried by TD7, from Table 2 and 3. Seasonal change also has effects on water quality of TD7. The TSS parameter reached the highest value in the wintertime because the amount of the wastewater in the canal was at its minimum level at this period in time. But due to fluctuating characteristics of the industrial discharges other parameters also differ with the discharge qualities.

Metal concentrations: Figure 1 shows the deviations of Cu, Zn, Pb, Ni, Mn, Fe and Cd contents in the canal sediments through the 5 sampling stations for seven observation months. Even at the 1st station, all the metals exist in the sediments, in considerable concentrations, implying the background pollution of TD7, by showing the minimum sediment concentrations in late spring and summer periods, when the agricultural wastewater discharge increase with the natural excess irrigation water.

The metal concentrations in the sediments did not show a synchronized deviation among stations, meaning the metal contamination sources differ in contaminant characteristics. Except Mn, Ni and Fe, metal concentrations in the sediments tend to decrease in dry season and increase during wet season, as expected because of washing of sediments in dry season, when the canal flow reaches its maximum due to the high irrigation rates. Although all the metal concentrations in the sediments were presumed to show the same pattern of deviation, Mn, Ni and Fe observed to differ from the other observed metals. While Mn and Fe concentrations did not show a regular divergence among 5 stations throughout the observation period, Ni showed inverted deviation pattern of Cu, Zn, Pb and Cd, that is the concentration of Ni in the sediments reaches its maximum in dry season and its minimum in the wet seasons.

The increase of Cu contamination in sediments at the 3rd station is observed to be due to textile and polyester producing utilities. The horizontal metal concentration through the canal is observed to give similar results with the one accomplished in Germany and Netherlands (Middelkoop, 2000; Gocht *et al.*, 2001; Martin, 2004). The maximum Zn and Cu values observed to exceed a number of times "Probable Effect Level" defined by the US EPA as the level above which metals have the potential to produce toxic biological effects (Christensen and Juracek, 2001).

In this study, the water quality of the TD7 drainage canal observed to decrease, in the months of April, May and June, April being the lowest, due to point and non-point pollutant sources. The point sources are the industrial utilities located near the canal. Non-point sources are principally result from agricultural activities. The water from the canal is frequently to be used in case incoming water quantity is insufficient for irrigation. But the water quality of the canal is identified as 4th quality class and is not suitable for agricultural use according to the current Turkish regulations.

Sediments of the TD7 drainage canal were polluted with metals. Metal concentrations are observed as the

Table 2: Chemical-physical properties of water observed at the stations

Station	pH	EC (µS)	TSS (mg L^{-1})	COD (mg L^{-1})	BOD_5 (mg L^{-1})
1	3.95-8.30 (7.33)	803-1585 (1073)	32-126 (68)	141-395 (224)	97-222 (142)
2	6.71-7.69 (7.26)	837-1579 (1095)	62-203 (123)	350-1335 (568)	179-708 (327)
3	6.79-7373 (7.18)	849-1937 (1237)	38-205 (125)	236-1339 (576)	157-774 (344)
4	6.91-7.51 (7.22)	734-1664 (1097)	32-210 (121)	197-787 (398)	116-447 (235)
5	6.92-7.56 (7.36)	802-1624 (1069)	30-202 (91)	68-428 (267)	122-254 (172.5)

Table 3: Microbiological properties of water observed at the stations, given as min-max

St.	Total aerobic messofilic bacteria (cfu mL^{-1})	Total coliform (MPN mL^{-1})	*E. coli* (MPN mL^{-1})
1	1.3×106-7.9×10^6	>1100-1100	1100->1100
2	7.0×10^5-5.8×10^6	>1100	>1100
3	3.3×10^5-1.4×10^6	>1100-1100	1100->1100
4	3.1×10^5-4.1×10^6	>1100-1100	1100->1100
5	1.5×10^5-4.5×10^6	>1100-250	1100->1100

maximum level where the industrial wastewater discharge occurs. Sediments are polluted with the metals, especially with Zn and Cu, as soon as the wastewaters enter the canal. It was also concluded that, after late spring and early summer periods, when the water flow is the maximum, sediment of the canal tends to be washed off from its metal content. Thus, the tread of heavy metal pollution persists in the Seyhan River and other main drainage canals.

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