Impact of Treated Industrial Effluents on Adam Sohaba Distributory Water at Sadiqabad (Pakistan) – A Case Study

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Summary: A study was carried out to investigate the impact of treated effluents of Fertilizer Plant on seasonal variations in physico-chemical parameters of Adam Sohaba Distributory water at Ahmaddali, Sadiqabad. Water samples were collected and analyzed on monthly basis for the period of ten months. Results indicated that air and water temperatures, light penetration and photoperiod showed higher values in summer than winter season. The values of turbidity, boiling point, pH, dissolved O_2, acidity, alkalinity, residual sodium carbonates were decreased in mixed water as compared to distributory water in almost all months while the values of viscosity, surface tension, conductivity, free CO_2, carbonates, bicarbonates, total hardness, total solids, total volatile solids, total dissolved solids, total volatile dissolved solids, sodium, calcium, magnesium, chlorides and sodium adsorption ratio were slightly increased in mixed water indicating the effect of treated industrial effluents. The monitored parameters were compared with water quality standards and most of them were found to be in the permissible limits indicating the proper functioning of wastewater treatment plant. The comparative study of Adam Sohaba Distributory water before and after mixing the treated effluents revealed that there was slight difference in water quality parameters. On the other hand, overall water quality parameters varied significantly which may be due to addition of urban wastes.

Introduction

Water is essential for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is most poorly managed resources in the world [1]. In urban areas, the careless discharge of industrial and municipal wastes is the major cause to poor the water quality [2]. In developing countries, rivers are the end points of domestic sewage and industrial effluents. If these wastes are not properly treated, they can pollute groundwater [3].

The demand of fresh water has increased with increase in population, economic activity and industrialization. Urbanization has also changed the pattern of freshwater utilization which caused a severe misuse of natural water resources. Due to direct discharge of untreated domestic sewage and industrial wastes into rivers, lakes and drains; the purity of these water bodies can no longer be maintained [4, 5].

In Pakistan, 69% water is used for agriculture, 23% for industrial and 8% for domestic purposes. Groundwater is mainly used for drinking purpose and Punjab Province is taking the major share of this aquifer and its quality is deteriorating with the passage of time as the ground water of Lahore has been seriously contaminated up to 700 ft depth. Industrial effluents are disposed into canals or rivers through open drains. About 9000 million gallons of wastewater is discharged daily from industrial sector [6, 7]. In Pakistan, only 2% of wastewater is treated [8]. Majority of wastewater treatment plants in developing countries are non-existent or function inadequately [9]. Wastewater in partially treated, diluted or untreated form is used by farmers to grow different crops [10], about 20 million hectares are irrigated globally [11] because:

1. it is the only water source available round the year for irrigation.
2. it reduces the need for fertilizer application.
3. its use involves less energy even when pumping.
4. it generates additional income and employment opportunities from cultivation of high-value crops such as vegetables [12].

Contamination of fresh water bodies due to fertilizer wastes is becoming a great concern as they cause eutrophication and threatened the ecological health especially by drastic changes in microbial fauna and flora which are largely responsible for natural oxygen depletion [13]. In fertilizer production,

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consumption of water for one tone urea varied from 9 to 40 m^3 at 90 % operating capacity of plant. Fertilizer plants mostly emerge pollutants as a part of liquid effluents, generally having high values of pH, ammonia, acidity or alkalinity, organic matter, nitrogen, potassium, etc. Their direct disposal in water bodies causes harmful diseases and has disastrous effect on living organisms [14].

To check irrigation water quality, different parameters are selected by considering their impact on crop production, livestock health and human health. So, crop production is evaluated by considering salinity (electrical conductivity or total dissolved solids), sodicity (residual sodium carbonate, sodium adsorption ratio) and toxicity due to specifications that affect sensitive crops. To avoid the problems while using poor quality water, there must be planning to ensure that the quality of water available is put to be best use [15].

Since most of the wastewater is being discharged into surrounding water bodies, which disturbs the ecological balance and deteriorates the water quality, therefore the present work was carried out to study the impact of treated industrial effluents on monthly variations in physico-chemical parameters of Adam Sohaba Distributory water at Sadiqabad, Pakistan.

Results and Discussion

Water quality is the summation of all physical, chemical, biological and aesthetic characteristics of water that influence its beneficial use. Any characteristic of water in production systems that affects survival, reproduction, growth and production of aquaculture species, influence decisions, causes environmental impacts, or reduces product quality and safety can be considered as water quality variable [16].

Temperature is an important parameter which directly related with the chemical reaction in the water biochemical reactions in the living organisms. In present study, the overall range in water temperature observed was 16.5 to 32.5°C while air temperature was minimum (20°C) in September and maximum (41.7°C) in June. Air and water temperatures showed an increasing trend reaching peak in June and gradually declined confirming the usual phenomena found in most studies [17]. The maximum clouds (>50%) were observed in September and October and absent in April, May and August. There was no rainfall in all months from March to December during sampling dates. Photoperiod was maximum (14.05 hours) in June and minimum (10.14 hours) in December. The maximum light penetration (14.5 cm) was observed in July and minimum (7.7 cm) in December at both sites before and after mixing the treated effluents. Light penetration showed an increasing trend from March till July then decreased from August till December (Table-1). Rath [18] stated that primary productivity depends on the concentration of nutrients, light and temperature. Both the light and temperature are external factors which are called as driving variables while nutrient concentration is linked dynamically with growth.

The maximum water density (1.009 and 1.005 g L^{-1}) and specific gravity (1.023 and 1.008) were observed in distributory water before and after mixing treated effluents, respectively; while the minimum values of water density (1.002 and 1.003 g L^{-1}) and specific gravity (1.003 and 1.007) were found in DW and MW, respectively (Table-1). The maximum values of both density and specific gravity decreased in mixed distributory water clearly indicate the impact of effluents. The boiling point was ranged 96.8 to 99.9°C in canal water while in mixed water 96.1 to 99.9 °C. In majority of mixed water samples boiling point slightly decreased (Table-2).

In distributory water sample, the turbidity ranged 106 to 596 mg L^{-1} while in mixed water ranged 104 to 593 mg L^{-1} with slight decrease in mean values 253 and 249 mg L^{-1}, respectively (Table-2). Turbidity showed significant ($p<0.05$) positive correlation with pH (Table-6). Phiri *et al.* [19] reported the turbidity range from 97.7 to 253 mg L^{-1} in river water receiving industrial effluents at different points. Higher turbidity reduces photosynthesis and production of dissolved oxygen by restricting the light penetration [20]. The absolute viscosity was observed maximum (0.968 mN S m^{-2}) in September and minimum (0.791 mN S m^{-2}) in May in DW while in MW ranged 0.867 to 0.993 mN S m^{-2} with slight increase in almost all months (Table-2). Viscosity showed similar increasing trend with boiling point and dissolved solids i.e. more the solids more the viscosity and boiling point. Surface tension ranged from 66.48 to 74.02 dynes cm^{-1} in DW, with maximum value in December and minimum in October while in MW ranged 70.04 to 74.03 dynes cm^{-1} (Table-2). Surface tension of water changes with the change in temperature and the content of dissolved solids [21]. The humidity was maximum (86%) in December and minimum (21%) in April (Table-2).

Table-1: Monthly variation in physical parameters of Adam Sohaba Distributory water (DW) and mixed water (MW).

Months	Parameters										
	Temperature (°C)		Clouds (%)	Rain	Photoperiod (Hours)	Light Penetration (cm)		Density (g L^{-1})		Specific gravity	
	Air	Water				DW	MW	DW	MW	DW	MW
Mar	24.5	20.2	<25	No	12.20	8.1	8.0	1.003	1.003	1.007	1.007
Apr	28.4	26.0	No	No	13.07	9.0	9.0	1.004	1.004	1.006	1.007
May	40.0	31.6	No	No	13.51	9.5	9.1	1.004	1.004	1.007	1.007
Jun	41.7	32.5	<25	No	14.05	12.0	11.5	1.004	1.005	1.007	1.008
Jul	31.3	26.0	<25	No	13.41	14.5	14.5	1.002	1.004	1.003	1.007
Aug	27.5	22.0	No	No	13.00	9.8	9.6	1.004	1.004	1.007	1.007
Sep	20.0	17.5	>50	No	12.07	9.1	9.1	1.019	1.004	1.023	1.007
Oct	32.0	23.6	>50	No	11.10	10.5	10.0	1.004	1.004	1.007	1.007
Nov	26.5	19.8	<25	No	10.29	8.3	8.3	1.004	1.004	1.006	1.007
Dec	23.8	16.5	<25	No	10.14	7.7	7.7	1.004	1.004	1.007	1.007

Table-2: Monthly variation in physical parameters of Adam Sohaba Distributory water (DW) and mixed water (MW).

Months	Parameters											
	Turbidity (mg L^{-1})		Absolute viscosity (mN S m^{-2})		Kinematic viscosity		Surface tension (dynes cm^{-1})		Humidity (%)		Boiling point (°C)	
	DW	MW	DW	MW	DW	MW	DW	MW	Max.	Min.	DW	MW
Mar	295	269	0.908	0.924	0.904	0.919	70.07	72.64	81	47	97.9	98.3
Apr	106	104	0.889	0.946	0.886	0.942	71.32	74.03	40	21	99.3	97.4
May	445	365	0.791	0.919	0.787	0.915	70.26	72.66	42	26	96.8	96.1
Jun	596	593	0.931	0.911	0.927	0.906	71.30	71.36	58	35	98.9	99.4
Jul	226	195	0.911	0.993	0.908	0.989	72.52	75.43	65	52	99.6	99.9
Aug	183	178	0.897	0.913	0.893	0.908	69.29	71.35	62	31	99.9	99.9
Sep	217	231	0.968	0.867	0.949	0.864	68.71	72.64	75	48	99.9	99.5
Oct	192	176	0.860	0.959	0.857	0.956	66.48	71.30	67	32	99.7	99.9
Nov	122	249	0.944	0.959	0.940	0.955	68.82	70.04	82	36	99.6	99.5
Dec	148	133	0.953	0.967	0.949	0.963	74.02	72.65	86	40	98.8	99.2

Table-3: Monthly variation in chemical parameters of Adam Sohaba Distributory water (DW) and mixed water (MW).

Months	Parameters											
	pH		Conductivity (µS cm^{-1})		Dissolved O_2 (mg L^{-1})		Free CO_2 (mg L^{-1})		Carbonates (mg L^{-1})		Bicarbonates (mg L^{-1})	
	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW
Mar	6.82	6.73	352	495	3.82	3.98	4.55	5.15	Nil	Nil	240	330
Apr	7.16	7.00	647	1155	4.39	4.36	3.76	2.97	Nil	Nil	264	416
May	7.26	7.18	398	552	2.99	2.42	4.20	3.76	Nil	Nil	260	302
Jun	7.52	7.33	335	368	3.53	2.90	4.36	4.75	45	81	204	210
Jul	7.15	6.96	286	556	2.06	1.89	5.15	3.96	10	50	230	250
Aug	6.89	6.85	395	824	2.75	3.86	5.74	4.55	Nil	Nil	292	280
Sep	7.07	7.04	404	445	2.57	3.75	6.53	5.94	20	Nil	296	276
Oct	6.87	6.90	406	633	3.11	3.66	4.95	4.16	Nil	Nil	260	270
Nov	6.86	7.26	378	463	2.33	2.99	5.54	4.36	18	20	284	360
Dec	7.48	6.54	366	424	2.86	2.38	7.13	5.15	Nil	Nil	260	350

The monthly variation in pH of distributory water ranged from 6.82 to 7.52 and in mixed water 6.54 to 7.33. In DW, maximum pH value (7.52) was observed in June and minimum (6.82) in March; while in MW, maximum value (7.33) was found in June and minimum (6.54) in December (Table-3). The pH values showed significant ($p<0.05$) positive correlation with water temperature and turbidity (Table-6). In present investigation, pH slightly decreased in due to mixing of treated effluents from Fertilizer Plant. Results are in accordance with Kumar *et al.* [22]. Low pH interferes with oxygen uptake and reducing activity of feeding [23]. The electrical conductivity (EC) ranged 286 to 647 µS cm^{-1} in DW with maximum value in April and minimum in July; while in MW, ranged 424 to 1155 µS cm^{-1}. EC showed significant ($p<0.05$) inverse correlation with free CO_2 (Table-6). Malik *et al.* [24] recommended the suitable limit of EC <1000 µS cm^{-1}. The fluctuations in EC are due to fluctuation in total dissolved solids and salinity [25]. In DW, maximum dissolved oxygen (4.39 mg L^{-1}) was observed in April and minimum (2.06 mg L^{-1}) in July while in MW, dissolved oxygen reduced with a range from 1.89 to 4.36 mg L^{-1}. The level of dissolved oxygen decreased in almost all months due to mixing of effluent which suggested that the industries were releasing high oxygen demanding organic substances [26]. Free CO_2 ranged 3.76 to 7.13 mg L^{-1} in DW while in MW 2.97 to 5.94 mg L^{-1} (Table-3). Dissolved oxygen showed inverse relation with free CO_2. Dissolved oxygen is very crucial for survival of aquatic organisms and it is also used to evaluate the degree of freshness of river [26]. Carbonates were present only in June, July and November samples of both sites but in high concentration in mixed water ranged from 20 to 81 mg L^{-1}. In DW, the maximum bicarbonates (296 mg L^{-1}) were observed in September and minimum (204 mg L^{-1}) in June; while in MW, bicarbonates increased with maximum value (416 mg L^{-1}) in April (Table-3).

In DW, acidity ranged 8.3 to 23 mg L^{-1} with maximum value in December and minimum in April; while in MW, acidity slightly increased except in April, with maximum value (29 mg L^{-1}) in December and minimum (6.5 mg L^{-1}). Acidity showed significant ($p<0.05$) inverse correlation with hardness (Table-6). 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 [26]. The mean concentration of total hardness in DW was 271.5 mg L^{-1} as $CaCO_3$ and in MW 298.8 mg L^{-1} as $CaCO_3$. At both sites, the total hardness values were very high as the value of total hardness more than 75 mg L^{-1} is undesirable for fish production [27]. The alkalinity ranged 128 to 220 mg L^{-1} in DW while in MW, alkalinity decreased throughout the study period due to addition of treated effluents, ranged from 88 to 174 mg L^{-1} (Table-4). Total hardness showed highly significant ($p<0.001$) positive correlation with EC and significant ($p<0.05$) positive correlation with dissolved O_2 (Table-6). The concentrations of total solids (TS), total volatile solids (TVS), total dissolved solids (TDS) and total volatile dissolved solids (TVDS) increased in distributory water after mixing of treated effluents. In mixed water, mean values increased as TS from 79.6 to 97.2 mg L^{-1}, TVS from 13.6 to 19.7 mg L^{-1}, TDS from 52.1 to 55.2 mg L^{-1} and TVDS from 10.5 to 13.1 mg L^{-1} (Table-4). Wastewater is more saline than freshwater because salts are added to it from different sources [28]. The increase in total dissolved solids is not a risk factor for human health but his can affect the taste and odour of drinking water and overall quality of the water and soil [29].

The mean values of sodium adsorption ratio (SAR) fluctuated from 1.54 (CW) to 2.01 (MW) with maximum value 3.90 in August. SAR showed significant ($p<0.05$) positive correlation with EC and non-significant ($p\geq0.05$) correlation with all other parameters (Table-6). The SAR value increased in mixed water due to increase in Na^+ concentration. The mean concentration of Na^+ and Cl^- increased from 1.55 to 2.73 me L^{-1} and 1.46 to 1.86 me L^{-1}, respectively, in mixed distributory water with maximum Na^+ 6.08 me L^{-1} and chlorides 3.3 me L^{-1} in April (Table-5). Excess levels of certain ions, such as Na^+, Cl^-, cause ion-specific effects leading to toxicity or deficiency of certain nutrients in plants [30]. Simmons *et al.* [31] found that EC and SAR levels increased 51 and 63%, respectively, in wastewater-irrigated soils than freshwater-irrigated fields. The SAR value <6 is suitable for irrigation water [24]. Residual sodium carbonates (RSC) ranged from 0.05 to 1.64 me L^{-1} in DW while absent from April to July similarly in mixed water RSC calculated only in four months ranged from 0.02 to 1.20 me L^{-1} (Table-5). Richards [32] and Muhammad [33] recommended suitable limit of RSC less than 1.25 me L^{-1}.

Irrigation with wastewater may impact groundwater quality. In well-drained soils, there is the possibility of movement of salts and other contaminants through the soil profile into unconfined aquifers [34]. Azizullah *et al.* [35] concluded that improper disposal of municipal and industrial effluents and indiscriminate use of agrochemicals in agriculture are the main factors contributing to the deterioration of water quality and are responsible for public health problems. Water shortage forced the farmers to use wastewater without checking its quality which ultimately cause heavy metal contamination in soil and plants. The use of wastewater for irrigation purpose resulted in 248 and 260% increase in cadmium contents at 0-15 cm depth of soils as compared to tube-well and canal water irrigation, respectively [36].

Table-4: Monthly variation in chemical parameters of Adam Sohaba Distributory water (DW) and mixed water (MW).

Months	Parameters											
	Acidity (mg L^{-1})		Hardness (mg L^{-1} as $CaCO_3$)		Alkalinity (mg L^{-1})		Total Solids (mg L^{-1})		TVS (mg L^{-1})		TDS (mg L^{-1})	
	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW
Mar	9.5	10.5	265.4	305.2	138	122	97	61	21	13	47	34
Apr	8.3	6.50	290.2	443.1	186	122	49	83	14	29	43	71
May	11.5	12.4	285.0	340.8	220	136	66	84	03	06	55	22
Jun	14.9	19.0	320.9	233.4	168	144	23	78	05	36	19	60
Jul	14.6	13.3	250.3	235.5	128	130	32	45	15	07	29	47
Aug	9.6	15.7	296.5	360.3	170	88	137	159	14	37	107	103
Sep	14.0	18.0	237.0	290.1	154	138	98	131	15	29	85	61
Oct	10.6	12.8	282.6	333.7	160	124	98	140	05	11	37	39
Nov	10.2	13.2	290.6	240.1	158	148	108	120	28	12	35	55
Dec	23.0	29.0	196.6	205.9	182	174	88	71	16	17	64	60

Table-5: Monthly variation in chemical parameters of Adam Sohaba Distributory water (DW) and mixed water (MW).

Months	TVDS ($mg\ L^{-1}$)		Sodium ($me\ L^{-1}$)		$Ca^{2+}+Mg^{2+}$ ($me\ L^{-1}$)		Chlorides ($me\ L^{-1}$)		SAR		RSC ($me\ L^{-1}$)	
	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW	DW	MW
Mar	19	11	1.32	1.80	2.20	3.15	1.1	1.9	1.26	1.44	0.20	0.15
Apr	13	23	3.83	6.08	2.64	4.47	3.1	3.3	3.33	2.72	Nil	Nil
May	03	05	1.38	2.02	2.60	3.50	1.5	2.6	1.21	1.52	Nil	Nil
Jun	04	19	0.15	1.49	3.20	2.19	1.8	1.2	0.11	1.42	Nil	Nil
Jul	11	07	0.36	3.08	2.50	2.48	0.9	1.8	0.32	2.71	Nil	0.02
Aug	04	23	1.75	4.64	2.20	3.60	1.3	2.0	1.67	3.90	0.72	Nil
Sep	14	12	1.67	1.55	2.37	2.90	1.2	1.8	1.53	1.29	0.59	Nil
Oct	04	08	1.41	2.83	2.65	3.50	1.4	1.9	1.22	2.14	0.05	Nil
Nov	20	11	0.88	2.23	2.90	2.40	1.1	1.1	0.84	2.04	0.06	1.20
Dec	13	12	2.70	1.54	1.96	2.70	1.2	1.0	3.46	1.32	1.64	0.80

Table-6: Relationship among physico-chemical parameters of Adam Sohaba Distributory water affected with treated effluents.

Correlation Matrix	WT	LP	Turbidity	pH	EC	DO	Free CO_2	Acidity	Hardness	TS
LP	0.505^{NS}									
Turbidity	0.643*	0.229^{NS}								
pH	0.626*	0.289^{NS}	0.656*							
EC	0.128^{NS}	-0.044^{NS}	-0.534^{NS}	-0.107^{NS}						
DO	-0.240^{NS}	-0.460^{NS}	-0.260^{NS}	-0.109^{NS}	0.563^{NS}					
Free CO_2	-0.577^{NS}	-0.252^{NS}	0.173^{NS}	-0.254^{NS}	-0.696*	0.018^{NS}				
Acidity	-0.355^{NS}	-0.126^{NS}	0.096^{NS}	-0.343^{NS}	-0.587^{NS}	-0.454^{NS}	0.621^{NS}			
Hardness	0.212^{NS}	-0.212^{NS}	-0.333^{NS}	0.008^{NS}	0.876**	0.710*	-0.552^{NS}	-0.695*		
TS	-0.279^{NS}	-0.291^{NS}	-0.189^{NS}	0.109^{NS}	0.185^{NS}	0.488^{NS}	0.170^{NS}	-0.013^{NS}	0.316^{NS}	
SAR	0.055^{NS}	0.305^{NS}	-0.428^{NS}	-0.081^{NS}	0.690*	0.238^{NS}	-0.478^{NS}	-0.358^{NS}	0.469^{NS}	0.378^{NS}

ns = non significant ($p \geq 0.05$), * = significant ($p < 0.05$), ** = highly significant ($p < 0.001$)

WT-Water Temp., LP-Light Penetration, DO-Dissolved Oxygen, TS-Total Solids, SAR-Sodium Adsorption Ratio

Experimental

a. Study Site

The study site is located at Ahmaddali (*longitude* 70° 12' 5" E and *latitude* 28° 21' 47" N), Sadiqabad, which is about 2 km in west of Sadiqabad City and about 3 km in east of Goth Machhi (Fig. 1). Adam Sohaba Distributory branches out from Abbasia Link Canal which in turn originates from Indus River through Panjnad Headworks. Adam Sohaba Distributory flows through the city roughly dividing the old and new city, receiving maximum urban sewage. From this distributory, the Sianwar Minor and Chandrami Sub-Minor are fed which irrigate many villages. The biggest fertilizer producing units in Pakistan is located at Goth Machhi which is about 5 km away from Sadiqabad City. A wastewater treatment plant having capacity 210 $m^3\ hr^{-1}$ has been installed at FFC to maintain National Environmental Quality Standards [37]. Adam Sohaba Distributory water is supplied to FFC Urea Plant through a water channel. The used water mixed with treated effluents is dumped back in distributory through a separate water channel at Ahmaddali.

b. Collection of Samples

Two sites (before and after mixing of treated effluents) were selected for sampling (Fig. 1). These sites were suitable for comparative study of water quality parameters because the treated effluents are properly mixed here and the depth and flow of water was maximum. The sampling period was expanded over 10 months. The samples were taken in clean 1.5 liter plastic bottles on monthly basis. The bottles were labeled date, time and name of sample with the help of water proof marker.

c. Methodology

At the time of water sampling, the air and water temperatures were recorded by using alcoholic thermometer. Light penetration was recorded with the help of Secchi's disc. Boiling point was measured by using mercury thermometer. Sunrise and sunset times were recorded to calculate the photoperiod. Humidity was measured by using "Whirling Psychrometer". The pH and conductivity were measured by using pH meter (Model HI-8417) and conductivity meter (Model AGB-1001), respectively. Dissolved O_2 was measured with portable O_2 meter (Model HI 9147-04, HANNA). Density, specific gravity, viscosity and surface tension were determined by following the methods as described by Nabi *et al.* [38]. While all other parameters including; turbidity, free CO_2, alkalinity, carbonates, bicarbonates, acidity, total hardness, total solids, total volatile solids, total dissolved solids and total volatile dissolved solids were determined by the methods as described by Boyd [25]. Chlorides, sodium absorption ratio (SAR) and residual sodium carbonate (RSC) were determined by using methods of USDA Handbook-60 [32].

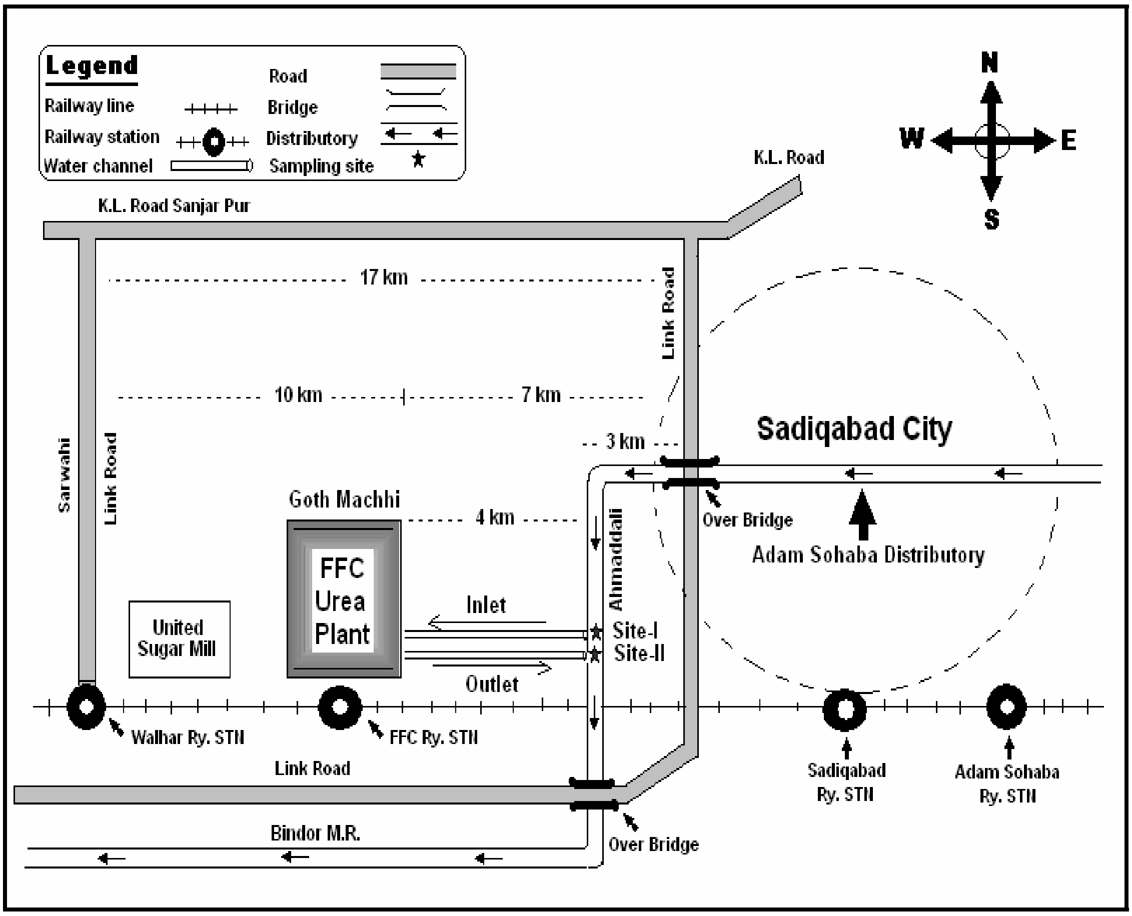

Fig. 1: Layout showing sampling sites.

d. Statistical Analysis

The data were statistically analyzed to find out significant relationship among various parameters by using MSTATC program (version 2.10).

Conclusions

On the basis of measured physico-chemical parameters, it may be concluded that the treated effluents from Fertilizer Plant have low impact on water quality of Adam Sohaba Distributory. Although, the values of some water quality parameters were lower than the permissible limits indicating the proper functioning of wastewater treatment plant installed at Fertilizer Plant. Before mixing of effluents, the range of some parameters was slightly high which may be due to addition of city sewage. It is, therefore, recommended that careless disposal of urban wastes should be discouraged and if possible a plant should be installed for the treatment of city sewage to conserve the fresh water quality.

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