

Pollution of Tanjero River by Some Heavy Metals Generated from Sewage Wastewater and Industrial Wastewater in Sulaimani District

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Abstract

Tanjero river represents a permanent river located southwest of Sulaimani city about 7km. Qiliasan and Kani-Ban streams confluence to form Tanjero river near Kani-Goma village. Water samples were collected from fifteen sites along the Tanjero river during June 2007 up to January 2008 and analyzed for studying some physico-chemical properties and heavy metals contaminations.

The total hardness values recorded in the studied sites were ranged (204.96 – 388.06)mg/L.The values of (8-33.1) °C, (1.08-496) NTU were recorded for temperature and turbidity respectively, while the values of (0.64 - 9.19) mg / L, (7.26-8.64) and (362 – 1715) $\mu\text{S}\cdot\text{cm}^{-1}$ were recorded for dissolved oxygen (DO), pH and specific conductance.

The values of Cobalt (Co), Chromium (Cr) ,Iron (Fe), Manganese (Mn) and Nickel (Ni), concentration were ranged between, (1.80 to 2.39), (0.2 to 3.31) , (2.13 to 2.55), (0.08 to 3.29) ,and (0.51 to 1.72) mg/L respectively .

The result indicates significant differences ($P \leq 0.05$) for the sampling events with LSD (Least Significant Differences) value of 0.01 for Co Fe, and Ni, while 0.03 and, 0.06 for Cr and Mn respectively. The Copper(Cu) concentration in all studied water samples was within the acceptable levels which ranged (0.11 to 0.51) mg/L .

Tanjero river and tributaries were polluted with heavy metals (Fe, Mn, Ni, and Cr) resulted from the impact of sewage wastewater according to water quality standard EU, 2004; USEPA, 2005; Canada, 2005 and WHO, 2006 and should Construct a plant of treatment for treating sewage wastewater of Sulaimani city before direct discharge to the river and it is quite essential to treat the ground water of the studied area before using .

Introduction

Tanjero river represents a permanent river located southwest of Sulaimani city by 7km. Qiliasan and Kani-Ban streams confluence to form Tanjero River near Kani-Goma village (Fig. 1). Also other small tributaries and springs discharging in the river. The studied area is located between(35° 35' 01") and (35° 28'44") North, (45° 21' 39") and (45° 26' 17") East .It represents 63.5 km² of the Tanjero river catchments area within Sulaimani city and elevated (656- 787) m above sea level (Mustafa, 2006). Length of the river is about 58 Km (Khamess, 1979), and pour the river in Darbandikan lake .

Hydrologic cycle, water availability and water quality depend on parameters of climate. Climate types correlate closely with soil types, moisture, evaporation and temperature regimes of climates determine the chemical reactions, organic activity and eluviations rates of soil (Christopherson, 1992).

Iron (Fe) is present in the wide variety of industrial wastewater including mining operations, or milling chemical industrial wastewater, dye manufacture, metal processing, textile mills, petroleum refining and others (Golterman, 1975). Iron exists in ferric or ferrous form depending on pH and dissolved oxygen concentration. At neutral pH and in the presence of oxygen, soluble ferrous iron is oxidized to ferric iron, which readily hydrolyzed to form the insoluble ferric hydroxide precipitate. Growths of iron bacteria, which concentrate iron, may cause taste and odor problems and lead to pipe restrictions, blockages and corrosion (ADWG, 2004).

Uncontaminated rivers and streams generally have low concentrations of manganese, ranging from 0.001 mg/L to 0.6 mg/L. High concentrations may occur in polluted rivers or under anoxic conditions such as at the bottom of deep reservoirs or lakes, or in groundwater (ADWG, 2004).

Nickel (Ni) is moderately toxic to most species of aquatic plants, though it is one of the least toxic inorganic agent to invertebrates and fish. The major source of Nickel in natural water is municipal wastewater followed by melting and the refining of nonferrous metals (Denton *et al.* 2001). Also mine drainage effluents are known to be the major contributors due to high concentrations of nickel found in the discharges (Finkelman, 2005).

Cobalt (Co) may enter the environment from both natural sources and human activities. Cobalt occurs naturally in soil, rock, air, water, plants, and animals. It may enter air and water, and settle on the land from windblown dust, seawater spray, volcanic eruptions, and forest fires and may additionally get into surface water from runoff and leaching when rainwater washes through soil and rock containing cobalt. Soils near ore deposits, phosphate rocks, or other industrial pollution may contain high concentrations of cobalt (ATSDR, 2004).

Chromium (Cr) is moderately toxic to aquatic organisms. Major coastal marine contributors of chromium are dominated by input from rivers, urban runoff, domestic and industrial wastewaters and sewage sludge (Denton *et al.* 1997). Also other major sources in the aquatic environment include the waste stream from electroplating and metal finishing industry (Callender 2003 and Finkelman 2005). All Cr compounds are considered toxic substances to organisms (Callahan, *et al.* 1979). The solubility of Cr compounds is strongly dependent on the form of Cr and physicochemical conditions of the water such as pH, oxygen and organic matters. Under oxygenated conditions, the

form Cr^{+6} is highly soluble in the water and under low pH, Cr^{+3} hydroxides may solubilize and remain as ionic Cr^{+3} (Eisler, 1986, Irwin, *et al.*, 1997b).

Copper(Cu) may also be present in wastewater from a variety of chemicals manufacturing processes employing copper or copper catalyst, Copper is present in uncontaminated surface water at very low concentrations, usually less than 0.01 mg/L. The concentration can rise substantially when water with a low pH and hardness remains in stagnant contact with copper pipes and fittings (ADWG, 2004).

Many studies were done on Tanjero river such as (Khamees ,1979) studied the ecology of Tanjero river and its tributaries(Al-Rawi ,1981) studied the petrology of Tanjero formation in Sulaimani region. (Muhammad Jaza ,1992) made facies analysis for Tanjero formation in Sulaimani area (Karim ,2004) made basin analysis study for Tanjero formation in Sulaimani area and (Muhammad, 2004) conducted an ecological and limnological study, whereas,(Mustafa, 2006) studied the impact of sewage discharge on the Tanjero river and its basin, including surface water, groundwater, agricultural soils and channel sediments.

The principle aims of this study is to study the effects of sewage water and other wastes generated from Sulaimani district on heavy metal content of Tanjero river and examining the pollution load caused by sewage effluents on the environment in the studied area.

Materials and Methods

Water samples were collected from fifteen Sites along the Tanjero river (Fig.1)from June 2007 up to January 2008 (Table 1).Water samples were collected using 1.5 liter polyethylene bottles for physico-chemical analysis after rinsing in laboratory with HCl and distilled water as described by (Bartram & Ballance, 1996). The collected samples were transported into the laboratory within 24 h of the collection and stored at (2-8) °C if they were not to be analyzed in the laboratory on the same day.

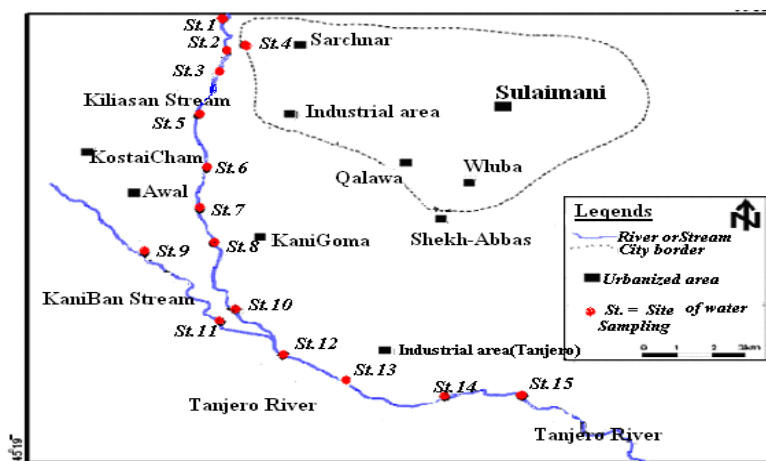


Figure (2) : Location map of the studied area.

Table(1): Sampling Site Description

<i>Sites</i>	<i>Description</i>	<i>Latitude</i>	<i>Longitude</i>
St.1	Near the Sarchinar cement Factory	35°35'34.67" N	45°22'41.86"E
St.2	Near the Sarchinar cement Factory	35°35'29.49" N	45°22'40.36"E
St.3	Near the Sarchinar cement Factory	35°35'23.18" N	45°22'39.12"E
St.4	Near the Sarchinar spring	35°35'18.31" N	45°22'34.11"E
St.5	Under Qiliasan bridge	35°34'44.31" N	45°22'35.01"E
St.6	Near Kostai-Cham and Awal village	35°33'47.78" N	45°22'26.55"E
St.7	Near Kostai-Cham and Awal village	35°32'57.47" N	45°22'24.76"E
St.8	Near Kostai-Cham and Awal village	35°32'8.71" N	45°22'26.75"E
St.9	Below Baba-Ali Bridge from the Kani-Ban stream	35°31'31.68" N	45°21'36.56"E
St.10	From Qiliasan stream before linking with Kani-Ban stream	35°28'59.12" N	45°24'45.99"E
St.11	From Kani-Ban stream before linking with Qiliasan stream	35°28'58.77" N	45°24'39.73"E
St.12	After linking Qiliasan stream with Kani-Ban stream	35°28'52.68" N	45°24'50.20"E
St.13	Near industrial area of tanjaro regions	35°28'39.98" N	45°25'21.65"E
St.14	Near industrial area of tanjaro regions	35°28'43.43" N	45°25'32.30"E
St.15	Below Tanjaro Bridge	35°28'43.26" N	45°25'46.45"E

Hydrogen Ion Potential (pH) of the water sample was measured using portable pH-meter, model (pH330i, 2004 WTW Company -Germany). The instrument was calibrated before using with standard buffer solution (pH= 4, 7, and 10) according to operating manual, 2004.

Water Temperature (°C) was measured in the field as described by (Bartram & Ballance, 1996).

Turbidity (NTU) of surface water was determined using portable turbidimeter; model (PHoto Flex Turb., 2006 WTW Company -Germany).

Dissolved Oxygen (DO) was measured using a special oxygen -sensitive membrane electrode (InoLab.OXi730,2004 WTW Company–Germany). Dissolved Oxygen values were recorded directly in the field and the results were expressed in mg/L.

Total Hardness (T.H) determined by (EDTA-disodium) titrimetric method as described by (APHA, 1999), using Erochrom Black T (E.B.T) indicator and Murrxide indicators. Total Hardness results expressed as mg CaCO₃.L⁻¹.

Heavy Metal Analysis: Six heavy elements, Cobalt (Co), Chromium (Cr), Copper(Cu), Iron (Fe), Manganese (Mn), and Nickel (Ni) were analyzed for surface water samples of Tanjaro river using atomic absorption spectrometry

(AAS) model (AAnalyst, 200, Perkin Elmer US) as described by (APHA, 1999).

Statistical and data analysis

Factorial Complete Randomized Design (CRD) was used for analysis of the data obtained. LSD test (Least Significant Differences) was used to determine the presence or absence of the significant differences between sampling events.

Results and Discussions

Water temperature recorded for the studied water throughout the entire sampling period is shown in (Table 2). It appears that the coldest temperature value was recorded in January, while the hottest one was during July, ranging between (8 to 33.1) °C. On the other hand, ambient temperature varies from maximum (33.75°C) in August (2007) to minimum (2.6°C) in January (2008).

Table 2: Some selected climatic parameters recorded during the June 2007 to January 2008 (from Bakrajo meteorological station)

Climate	2007					2008
	June	July	August	September	November	January
Air Temp. (C°)	30.05	27.10	33.75	28.05	13.85	2.60
Rainfall(mm)	0.00	0.00	0.00	0.00	10	49
Humidity (%)	15.60	12.42	13.70	11.59	35.25	48.32

The turbidity values of Tanjero river and its tributaries were ranged between (1.08 to 496) NTU and dissolved oxygen concentration showed a range from (0.64 to 9.19) mg/L during the studied period (Table 3).

The pH values of the present investigation lie in the alkaline side of neutrality and ranged between 7.26 and 8.64. (Table 4) .In the present study the highest pH value was recorded during June 2007. This could be resulted in an increase in both photosynthetic activity and sewage disposal loaded with high concentration of detergents (Maulood & Hinton, 1979; Anber, 1984 and Brower ,1990). While the lowest value was recorded in June 2007, this may be due to an increases in decomposition of organic matter (Aziz *et al.*, 2001). On the other hand, biological factors pH via the use of CO₂ in photosynthesis, raising the pH near the surface, and the generation of CO₂ in respiration, is lowering the pH near the bed (Wetzel, 1975). The pH values of all studied water during the studied period were within the desirable levels recommended by (WHO, 2006 & USEPA, 2004).

The values of specific conductance for the studied water ranged from (362 to 1715) μS.cm⁻¹ (Table 4). Total Hardness concentrations of Tanjero River and its tributaries ranged from 204.96 mg/L as CaCO₃ at (St.10) in January 2008, to 388.06 mg/L as CaCO₃ at (St.6) in August 2007 (Table 5) .

Statistical analysis of data indicates significant differences ($P \leq 0.05$) for the sampling events with LSD value of 74.44 .

The range was relatively lower than that recorded by Khamess (1979) (25 to 500) mg/L as CaCO_3 in Tanjero River; Mustafa (2006) .

The values of Iron (Fe) concentration were ranged from 2.13 to 2.55 mg/L. The minimum value was recorded at (St.3) during August 2007, while the maximum value was recorded at (St.5) during June 2007 (Fig. 2). The result indicates significant differences ($P \leq 0.05$) for the sampling events with LSD value of 0.01. On the other hand, the excess of Fe concentration may result from merging of Kliassan stream with sewage effluent of Sarchinar area. All water samples show pollution with Iron, because they exceed its level in water quality standard 0.2 mg/L according to (EU, 2004 and Canada, 2005) .

The concentration of Manganese (Mn) in the studied water were ranged from 0.08 to 3.29 mg/L. The lowest value was recorded at (St.2) during July 2007, while, the highest value was recorded at (St.8) during January 2008 (Fig. 3). The Results revealed to the significant differences ($P \leq 0.05$) for the sampling events with LSD value of 0.06

The highest value of Mn may be due to the direct effect of Kostai Cham and Awal sewage effluents on Tanjero river and its tributaries. Manganese concentration in Tanjero river and its tributaries exceed the recommended value (0.05 mg/L) according to (EU, 2004; USEPA, 2005 and Canada, 2005), and the recommended value 0.5 mg/L according to (WHO, 2006) .

Nickel (Ni) concentration in the studied water was within the range of (0.51 to 1.72) mg/L. The lowest value of Ni was recorded at (St.2, St.3, St.7, St.9, and St.11) during July, November 2007 and January 2008, while the highest values were recorded at (St.15) during November 2007 (Fig.4). Significant differences ($p \leq 0.05$) were recorded for the sampling events with LSD value of 0.01 However, comparative Ni concentrations were recorded in different Iraqi inland water by many authors Mustafa ,2006 reported that the total average concentration of Ni in Tanjero river and its tributaries were (1.45 mg/L) in surface water while in sewage wastewater were (1.49 mg/L). The value of 26.79 $\mu\text{g/L}$ was recorded in Sarchinar spring and Kliassan stream water (Muhammad, 2004). The excess concentration of nickel in the studied water may be resulted from sewage wastewater that are discharged to Tanjero river and its tributaries and industrial wastes in the Tanjero area may represent the secondary sources for pollution by nickel. According to (WHO, 2006; EU, 2004; and Canada, 2005) all studied water samples show high pollution by nickel, which exceed permissible level (20 $\mu\text{g/L}$). In the present study the concentrations of Cobalt (Co) were significantly ranged (1.80-2.39) mg/L recorded at St.6 and St.5 duringn (January 2008 and August &

November 2007) (Fig.5). However, significant differences ($p \leq 0.05$) were recorded for the sampling events with LSD value of 0.01. The high concentration of cobalt may result from mixing of Kliassan stream with sewage effluent of Sarchinar area.

Table (3): Water temperature, turbidity and dissolved oxygen values recorded for the studied water with the mean, during June 2007 till January 2008.

	Months	SITES															Mean	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Water temperature (C°)	2007	June	20.1	20	20.5	21.7	23.1	25.3	26.7	27.9	30	24.8	31.2	31.6	31.9	30.9	30.3	26.4
		July	33.1	30.6	32.7	33.1	32.6	32.8	31.2	30.3	29	25.6	26	26.8	23.1	22.7	26	29.04
		August	24.9	27.1	23.7	25.3	25.7	25.2	24.2	26.6	25.6	26.9	25.2	26.3	23.8	23.5	24	25.2
		September	22.6	22.3	18.7	19.2	21.2	19.4	17	21.9	18	29.4	27.8	26.9	25	27.3	26.5	22.88
		November	14.8	14.5	13.5	14.5	14.8	14.9	14	15.2	13.9	13.2	13.4	14.2	13.8	12.6	13	14.02
	January	11.4	10.2	10.4	9.8	8.8	8.5	10.3	8.8	8.0	8.4	8.4	8.9	8.5	8.9	9	9.22	
∑	Mean	21.15	20.78	19.92	20.6	21.03	21.01	20.57	21.78	20.75	21.38	22	22.45	21.02	20.98	21.47	21.13	
Turbidity (NTU)	2007	June	3.94	5.77	7.54	2.15	145	9.57	7.48	21.82	3.33	123.6	76.8	54.9	98.3	72.1	44.6	45.13
		July	2.54	3.1	11.5	4.01	39.4	8.13	6.76	19.9	4.93	242	15.8	31.1	67.9	67.4	37	37.43
		August	8.6	20.4	6.41	3.36	129	10.4	8.28	34.7	11.6	71.4	101	131	100	67.2	111	54.29
		September	1.15	2.33	1.15	1.59	21.1	6.43	6.98	22.9	1.84	167	289	95.3	158	150	213	75.85
		November	5.95	29.8	8.91	1.08	496	165	40.9	46.2	4.87	131	34.3	149	69.3	71.2	27.2	85.38
	January	7.72	6.55	36.7	1.2	139	141	180	142	5.97	97.1	106	92.6	118	96.3	96.8	84.46	
∑	Mean	4.98	11.33	12.04	2.23	161.58	56.76	41.73	47.92	5.42	138.68	103.82	92.32	101.92	87.37	88.27	63.76	
Dissolved oxygen (mg/L)	2007	June	5.56	5.65	5.38	5.72	3.89	4.75	4.95	4.67	5.22	4.62	4.26	5.09	3.89	4.95	4.87	4.90
		July	5.3	5.44	5.73	5.5	4.8	4.52	5.17	4.72	5.07	4.64	4.44	4.87	4.66	4.86	4.29	4.93
		August	5.87	6.6	5.74	5.58	4.93	5.32	4.88	4.79	5.87	4.23	4.91	4.08	4.18	4.19	4.7	5.06
		September	4.52	5.3	4.36	6.64	0.68	1.01	1.32	0.8	4.33	3.75	4.24	3.28	4.24	4.4	4.15	3.53
		November	4.39	5.68	4.38	5.45	3.1	0.64	4	2.62	2.22	1.92	3.17	2.35	2.4	3.84	2.42	3.24
	January	7.98	7.25	9.19	8.82	3.82	4.87	3.91	2.95	4.32	4.78	4.2	4.52	5.47	4.31	4.22	5.37	
∑	Mean	5.60	5.99	5.79	6.29	3.54	3.52	4.04	3.43	4.51	3.99	4.20	4.03	4.14	4.43	4.11	4.51	

Table (4): Hydrogen ion potential and electrical conductivity values recorded for the studied water with the mean, during June 2007 till January 2008.

PH	Months	SITES															Mean		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
PH	2007	June	7.43	7.30	7.77	7.63	7.66	8.2	8.14	7.99	8.64	7.52	7.76	7.54	7.65	7.75	7.74	7.78	
		July	7.26	7.72	7.75	7.76	7.53	7.95	8.3	7.46	7.38	7.46	7.63	7.51	7.36	7.42	7.42	7.59	
		August	7.46	7.77	7.64	7.76	7.38	7.84	8.19	7.6	7.54	7.77	7.6	7.65	7.54	7.55	7.65	7.66	
		September	7.35	7.53	7.59	7.89	7.56	7.79	7.75	7.55	7.56	8.14	7.77	7.91	7.68	7.62	7.73	7.69	
		November	7.86	8.27	7.93	8.12	7.86	7.84	8.21	7.94	7.95	8.11	7.97	8.09	7.96	7.97	7.96	8.00	
	2008	January	7.38	7.75	7.66	8.03	8	7.93	8.06	8.13	7.81	7.94	7.81	7.8	7.76	7.77	7.73	7.84	
		Mean	7.46	7.72	7.72	7.87	7.67	7.93	8.11	7.78	7.81	7.82	7.76	7.75	7.66	7.68	7.71	7.76	
	EC(μS/cm)	2007	June	488	500	484	653	676	505	502	491	426	793	922	836	665	687	673	620.07
			July	378	377	362	369	374	603	629	722	768	771	991	974	905	913	793	661.93
			August	511	431.1	503.2	487.1	936.2	946.2	944.9	957.3	731.1	1029	856.6	1012	973.8	973.8	989.4	818.86
September			493	518	595	531	930	1116	1118	991	814	982	767	1000	880	820	833	825.85	
November			577	582	623	595	879	989	1102	1219	913	1715	1172	1645	1237	1269	1263	1052	
2008		January	422	427	537	374	1154	1164	1189	1472	894	1033	1317	1179	1313	1298	1294	1004.47	
		Mean	478.17	472.52	517.37	501.51	824.87	887.16	914.09	975.39	757.69	1053.89	1004.26	1107.72	995.63	993.47	974.23	830.53	

Table (5): Total Hardness values recorded for the studied water with the mean, during June 2007 to January 2008.

	Months	SITES															Mean	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Total Hardness mg/L as CaCO ₃	2007	June	258.6	236.9	236.9	262.1	276.6	254.8	265.8	262.1	240.5	326.9	352.1	326.7	319.7	319.8	312.5	283.46
		July	236.9	244.3	276.7	262.4	312.4	330.5	319.6	323	355.4	341.4	344.6	326.6	341.3	337.7	334.2	312.46
		August	287.4	255	276.6	272.9	377	388.06	355.5	362.9	384.6	341.6	323.4	334.3	341.6	337.9	348.8	332.51
		September	262.1	244.1	280.2	251.4	366.9	362.9	323.3	355.5	348.6	359	301.7	341.1	337.7	337.7	330.4	320.18
		November	272.8	262.2	276.4	265.6	283.8	280.2	312.6	323.4	319.8	312.6	319.9	298.2	323.4	330.6	323.5	300.34
	2008	January	219.4	226.7	233.4	237	248	287.5	276.7	233.5	236.9	204.96	283.7	251.7	269.6	258.7	266	248.91
		Mean	256.19	244.86	263.37	258.57	310.78	317.32	308.9	310.08	314.31	314.40	320.89	313.10	322.24	320.41	319.23	299.64

Table (6): Heavy metals (Fe, Mn, Ni, Co, Cr, and Cu) values recorded for the studied water with the mean, during June 2007 to January 2008.

	Months	SITES															Mean	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Fe (mg/L)	2007	June	2.25	2.2	2.36	2.3	2.55	2.17	2.25	2.3	2.45	2.21	2.19	2.18	2.36	2.26	2.2	2.28
		July	2.24	2.33	2.38	2.26	2.28	2.16	2.22	2.4	2.28	2.45	2.27	2.24	2.4	2.31	2.21	2.30
		August	2.3	2.16	2.13	2.24	2.2	2.44	2.28	2.24	2.18	2.15	2.21	2.27	2.38	2.21	2.17	2.24
		September	2.2	2.22	2.17	2.17	2.36	2.41	2.24	2.27	2.35	2.19	2.23	2.21	2.23	2.41	2.38	2.27
		November	2.23	2.18	2.17	2.25	2.22	2.26	2.17	2.19	2.24	2.17	2.24	2.23	2.24	2.23	2.18	2.21
	2008	January	2.22	2.22	2.26	2.21	2.25	2.27	2.23	2.2	2.19	2.23	2.22	2.25	2.24	2.28	2.25	2.23
	Mean	2.24	2.22	2.25	2.24	2.31	2.29	2.23	2.27	2.28	2.23	2.23	2.23	2.31	2.28	2.23	2.26	
Mn (mg/L)	2007	June	0.14	1.5	0.22	0.29	1.56	2.25	1.16	1.45	2.35	2.24	0.88	1.6	1.35	1.78	1.75	1.37
		July	0.19	0.08	0.13	0.16	0.76	2.17	1.06	1.06	2.45	2.45	0.78	1.34	1.06	2.17	2.17	1.20
		August	1.03	1.45	1.64	1.22	2.21	2.19	1.12	1.24	2.62	2.64	1.23	1.35	1.03	1.78	1.33	1.61
		September	0.78	1.06	0.78	0.78	1.34	0.78	1.06	1.34	2.45	2.45	2.73	1.62	1.34	1.34	1.89	1.45
		November	1.06	1.89	0.76	2.73	1.06	2.17	1.89	1.89	1.34	1.62	0.78	2.73	2.17	0.78	1.34	1.61
	2008	January	0.78	1.34	1.62	1.89	2.17	2.17	2.17	3.29	2.73	1.89	1.98	2.17	1.06	1.89	1.62	1.92
	Mean	0.66	1.22	0.86	1.18	1.52	1.95	1.41	1.71	2.32	2.22	1.39	1.80	1.34	1.62	1.68	1.53	
Ni (mg/L)	2007	June	0.75	0.66	0.53	0.61	1.08	1.15	1.55	0.85	0.52	1.15	0.95	1.32	0.55	0.82	0.53	0.87
		July	0.79	0.65	0.51	0.58	0.72	0.86	0.53	0.65	0.51	0.86	0.51	0.65	0.53	0.65	0.52	0.63
		August	0.76	0.52	0.55	0.65	1.35	1.16	1.5	1.09	0.67	1.14	0.9	1.27	0.75	1.27	0.61	0.95
		September	0.73	0.64	0.57	0.53	1	1.14	1.15	0.72	0.65	0.65	0.93	0.72	0.65	0.79	0.58	0.76
		November	0.68	0.62	0.51	0.86	0.72	1.14	1	1.07	1.21	1.14	1.21	1.63	1.21	1.28	1.72	1.07
	2008	January	0.79	0.51	1	0.58	1.28	1.07	0.51	1.07	1	0.58	0.86	1.28	0.72	0.65	0.58	0.83
	Mean	0.75	0.60	0.61	0.64	1.03	1.09	1.04	0.91	0.76	0.92	0.89	1.15	0.74	0.91	0.76	0.85	

Continued

	Months	SITES															Mean	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Co (mg/L)	2007	June	2.32	2.23	1.99	2.22	2.08	2.15	1.87	2.07	1.86	2.22	2.25	1.95	2.25	2.09	1.98	2.10
		July	2.31	2.26	2.31	2.21	2.26	2.12	2.17	2.03	2.17	2.26	2.26	1.94	2.08	2.08	1.89	2.15
		August	2.2	2.22	1.95	2.2	2.39	2.14	2.15	2.08	1.98	1.88	1.95	1.95	2.25	2.03	1.95	2.09
		September	2.21	2.17	2.17	2.26	2.03	2.08	2.03	2.03	2.08	1.99	2.08	1.85	2.26	2.08	1.99	2.09
		November	1.99	2.21	1.94	1.85	2.39	1.89	2.17	1.99	1.99	1.85	1.94	1.89	1.85	2.08	2.08	2.01
	Yearly	January	1.94	1.99	1.89	1.85	2.08	1.8	1.85	2.08	1.99	1.94	1.85	1.99	1.99	1.85	1.99	1.94
	Mean	2.16	2.18	2.04	2.09	2.21	2.03	2.04	2.05	2.01	2.02	2.06	1.93	2.11	2.04	1.98	2.06	
Cr (mg/L)	2007	June	1.85	1.65	1.43	0.89	2.32	2.65	2.32	1.35	2.35	3.08	1.88	2.85	1.75	2.25	1.95	2.04
		July	1.87	2.53	2.02	0.76	2.31	2.42	2.31	0.20	2.98	3.09	1.76	1.87	2.02	1.87	1.98	1.99
		August	1.66	2.33	2.07	0.98	2.35	2.45	2.35	1.45	2.21	2.89	1.75	1.99	1.75	2.26	1.99	2.03
		September	1.64	1.64	1.76	1.45	2.64	2.53	2.53	1.31	1.42	3.2	2.2	1.09	1.98	2.2	1.2	1.92
		November	1.64	2.31	2.98	0.87	3.31	2.64	3.2	1.98	2.31	2.87	1.87	1.98	1.76	2.31	1.98	2.27
	Yearly	January	0.98	2.42	1.42	2.42	2.87	2.31	2.76	1.42	2.2	0.87	2.09	2.98	1.76	2.31	2.2	2.07
	Mean	1.61	2.15	1.95	1.23	2.63	2.50	2.58	1.29	2.25	2.67	1.93	2.13	1.84	2.20	1.88	2.05	
Cu (mg/L)	2007	June	0.34	0.35	0.25	0.36	0.33	0.35	0.25	0.46	0.25	0.5	0.46	0.25	0.35	0.35	0.24	0.34
		July	0.33	0.47	0.36	0.33	0.3	0.36	0.39	0.27	0.36	0.3	0.42	0.42	0.18	0.42	0.45	0.36
		August	0.32	0.26	0.18	0.35	0.37	0.42	0.26	0.34	0.2	0.33	0.43	0.22	0.32	0.18	0.22	0.29
		September	0.33	0.39	0.15	0.3	0.39	0.3	0.36	0.45	0.36	0.39	0.33	0.18	0.39	0.45	0.36	0.34
		November	0.24	0.15	0.27	0.39	0.39	0.45	0.33	0.45	0.34	0.51	0.45	0.45	0.36	0.42	0.33	0.37
	Yearly	January	0.35	0.36	0.36	0.33	0.36	0.51	0.27	0.36	0.24	0.3	0.33	0.45	0.33	0.11	0.21	0.32
	Mean	0.32	0.33	0.26	0.34	0.36	0.39	0.31	0.39	0.29	0.39	0.40	0.33	0.32	0.32	0.30	0.34	

The minimum value of Chromium (Cr) was 0.20 mg/L recorded at (St.8) during July 2007, while, the maximum value of 3.31 mg/L was observed at (St.5) during November 2007 (Fig.6). Statistical analysis of data showed significant differences ($P \leq 0.05$) for the sampling events with LSD value of 0.03. The higher concentration of Cr in Tanjero river and its tributaries is regarded as a direct effect of Sarchinar sewage effluents on Kliassan stream at St.5. In addition, sewage wastewater from Kliassan area may represent the other source of Cr in the studied waters. All studied water samples show high levels of Chromium (Cr), which exceed permissible level (0.05 mg/L) that is recommended by (WHO, 2006; EU, 2004; and Canada, 2005).

The lowest value of 0.11mg/L was recorded for Cooper (Cu) at St.14 during January 2008, while the highest value of 0.51 mg/L was recorded at St.6 during January 2008 (Fig.7). Results revealed to significant differences ($P \leq 0.05$) for the sampling events with LSD value of 0.004.

The excess Cu concentration may be resulted from sewage wastewaters that discharge to St.6. On the other hand, Sugar factory sewage effluents may have direct effect on Kliassan stream water. According to the previously mentioned guidelines and standards, and corresponding the present results, all the studied water samples were within the desirable copper levels .

Copper (Cu) may also be present in wastewater from a variety of chemicals manufacturing processes employing copper or copper catalyst. Copper is removed from wastewater by precipitation or recovery processes, which include ion exchange, evaporation and electro dialysis. However, there are also indications that biological activity is not directly related to the concentration of ionic copper (Ferrgusson, 2003). In addition, (Irwin, *et al.*, 1997a) stated that the toxicity of Cu is strongly influenced by conditions of the water, the hardness, alkalinity, salinity, organic level and pH .According to (Nriagu, 1979), mining and industrial activities are significant sources of Cu input into the aquatic environment. Cu from agricultural runoff is also considered as a considerable source for the aquatic ecosystem (Eisler, 1997).

Conclusions

- 1.The results indicate that the water in the stuy sites were ranged between hard and very hard.
- 2.Tanjero River and tributaries were polluted with heavy metals (Fe, Mn, Ni, and Cr) resulting from the impact of sewage wastewater that should be treated before direct discharge into the river especially at the Sts. No.5, 12, and 15 .

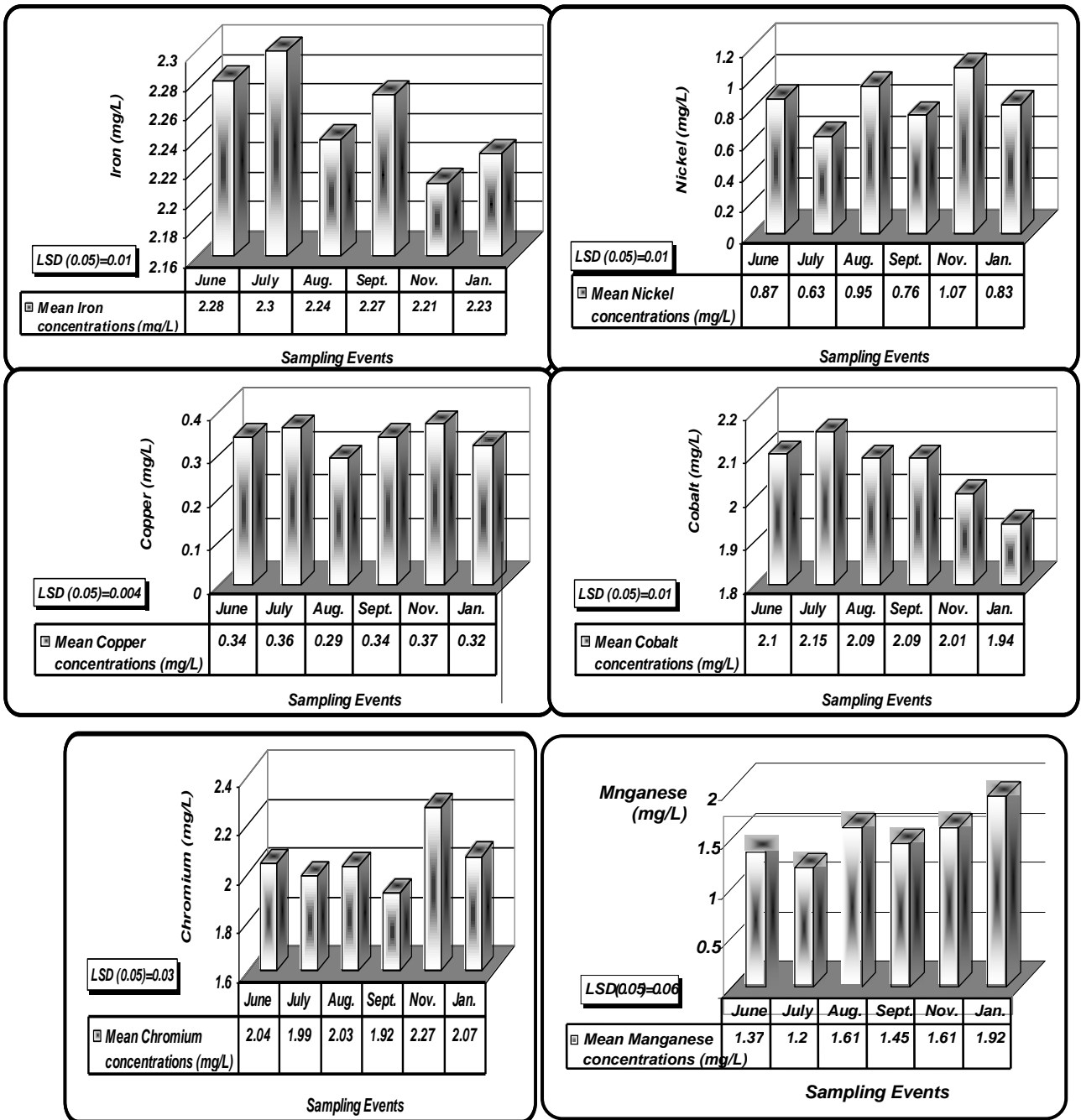


Fig. (2): Iron, Nickel, Copper, Cobalt, Chromium and Manganese concentration of Tanjero water samples during June 2007 to January 2008

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تلوث نهر تانجرو بالعناصر الثقيلة الناتجة عن مياه الصرف الصحي والنفايات الصناعية في محافظة السليمانية

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الخلاصة

نهر تانجرو نهر دائم يقع في الجنوب الغربي من مدينة السليمانية بحوالي (٧) كم يتكون النهر من النقاء جدولي قلياسان وكاني بان قرب قرية كاني كومه. أخذت عينات المياه من خمسة عشر موقعا على طول النهر خلال شهر حزيران ٢٠٠٧ ولغاية كانون الثاني ٢٠٠٨ وتم تحليلها من اجل دراسة بعض الخواص الفيزيائية وكيميائية والتلوث بالمعادن الثقيلة. تشير النتائج إلى أن المياه في محطات التي شملتها الدراسة تراوحت بين عسر وشديد العسرة وتراوحت درجة حرارة المياه وقيمة التعكر بين (٨ إلى ٣٣,١) درجة مئوية و(١,٠٨ إلى ٤٩٦) NTU على التوالي . بينما الأوكسجين الذائب ودرجة الحموضة والتوصيلية النوعية كانت (٠,٦٤ إلى ٩,١٩) ملغم / لتر، (٧,٢٦ إلى ٨,٦٤) و (٣٦٢ إلى ١٧١٥) مايكروسمنس / سم على التوالي. وأشارت النتائج إلى اختلافات معنوية ($P \leq 0.05$) وقيم مقياس التشتت الأدنى (LSD) (٠,٠١) للحديد والنيكل وبقيمة (٠,٠٣ و ٠,٠٦) للمغنيز والكروم على التوالي. في حين كان تركيز النحاس في جميع عينات المياه في حدود المرغوب فيها والتي تراوحت (٠,١١ إلى ٠,٥١) ملغم / لتر. أظهرت النتائج بان نهر تانجرو ورافده كانت ملوثة بالمعادن الثقيلة (الحديد والمغنيز والنيكل والكروم) الناتجة من مياه الصرف الصحي ومخلفات المصانع استنادا إلى معايير الاتحاد الأوروبي ٢٠٠٤ و وكالة البيئة الكندية ٢٠٠٥ ومنظمة الصحة العالمية ٢٠٠٦. وينبغي إنشاء معمل لمعالجة مياه الصرف الصحي في السليمانية (قرب جسر قلياسان، موقع النقاء جدول قلياسان مع جدول كاني بان وبعد جسر تانجرو) قبل تصريفها إلى النهر ومعالجة المياه الجوفية للمنطقة المدروسة قبل الاستخدام .