

## Contribution of Man – Made Activities to the Pollution of the Tigris within Mosul Area/IRAQ

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**Abstract:** This paper presents an overall view of major sources that may lead to the pollution of the Tigris within Mosul city. A stretch exceeding 20kms in length is selected that represents the “sick” path of the river. Many sites along the studied stretch are likely to affect the river quality in some way or another. Samples from 40 sources sites are taken for quality analyses These sources – as huge as 400000 m<sup>3</sup> a day – are characterized as (medium – strong) in composition. Such wastewaters with the pollutants they carry alter the river water quality rendering it unsuitable for beneficial uses. Such alterations – do leave –many negative consequences concerning human beings and aquatic life. It is found that domestic discharges are among the most important sources of pollution. Sanitary wastes are often discharged – untreated -into the Tigris. Other illegal practices such as in-house slaughtering add to the pollution as well. Industrial, tourist and institutional wastes put an additional burden on pollution of the river water quality. These wastes contain lead, chrome, and other heavy metals that may pose health risks. Wastewater treatment plants that exist in some sectors do not perform as they are expected. They need proper evaluation and rehabilitation. Eutrophication - a characteristic problem in lakes - finds an access to occur into the Tigris. This problem results from intensive use of detergents rich in nutrients (P&N compounds). In general, pollutants of different sources heavily affect the river water. Recovery and self purification of the river is estimated to occur at 40 km far from reference point. The paper concludes with the necessity of construction of a central treatment plant(s) or tackling the pollutants at their origin. The paper also stresses on importance of environmental education and awareness in order to combat pollution problems.

**Keywords:** Tigris, Surface water Pollution

### Introduction

The Tigris is considered the sole surface water resource in Mosul city/IRAQ. Its water is used for domestic, municipal, industrial, agricultural, and recreational purposes. Besides, the Tigris is thought to be the ultimate sink for all wastewater arising from above activities.

The Tigris had been put under monitoring for years. Many papers and theses were published regarding its sources of pollution, pollutants concentration, degradation in water quality, and other aspects [1-5].

This paper is another effort added to previous works trying to shed light on evaluating status of the river as it passes through a selected stretch within Mosul city. Such stretch includes the major point and non point sources of pollution that do affect river water quality and quantity.

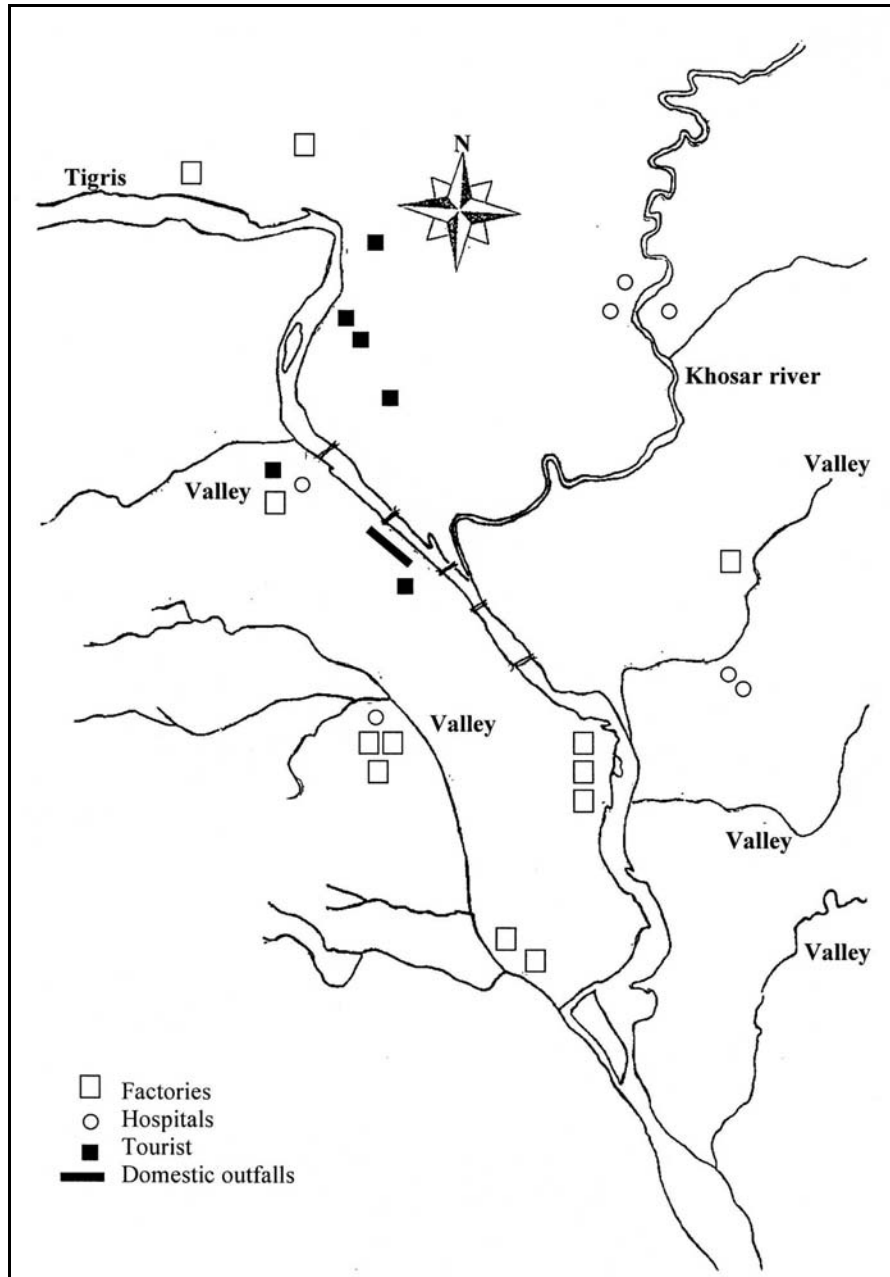
### Materials and Methods

A detailed survey was made to figure out the activities that might contribute to the pollution of the

Tigris within Mosul city (fig 1). More than (60) discharge sites were visited. Samples from (36) sites had been taken for quality characterization. Physical, chemical, and biological tests had been conducted on each adopting “the standard methods” (6, 7). Table 1 shows these tests.

**Table 1:** The Studied Characteristics

Characteristics	Studied Parameters
Physical	Turbidity, temperature, total solids TS, suspended solids SS, total dissolved solids TDS, color, odor
Chemical	Electrical conductivity EC, pH, alkalinity Alk., total hardness TH, chlorides Cl, sulphates SO <sub>4</sub> , Phosphates, PO <sub>4</sub> , organic load in terms of BOD <sub>5</sub>
Biological	Bacterial counts, chlorophyll



**Figure 1:** Pollution Sources of the Tigris River within Mosul city

**Results and Discussions**

The Tigris - like any other water resource - is subjected to numerous sources of pollution. Municipal discharges, industrial pollutants, agricultural activities residuals, direct runoff, tourism, illegal practices, atmospheric pollution, and others are few examples. The most important sources covered for the purpose of this paper are listed in table (2).

**Table 2:** Major Contributor Sites & Characteristics to the Tigris Pollution

Site	No.	Remarks
Hotels and Tourist Establishments	6	Some of these sites discharge their wastes into insecure septic tanks and may contaminate ground water due to seepage. Other sites possess their own compact waste treatment plants that often are shortly operated
Hospitals and Health-Care Institutions	9	Some sites discharge wastes into sewers connected to the river or the wastes are discharged to insecure septic tanks that may lead in some way or another to ground water pollution
Industries and Factories	18	Majority of sites discharge their wastes to storm or domestic sewers connected to the river. Some sites discharge the wastes to lagoons or large pits .The latter may seep to ground water. Some industries hope to have their own treatment plants in the nearby future.
Valleys	6	These valleys discharge waste load into the river directly. These wastes comprise those generated due to various domestic and industrial activities. Such wastes are sometimes used for agricultural purposes.

It is estimated that as huge as 400000 m<sup>3</sup> of wastewater is daily discharged - untreated - into the river. This is equivalent to 17000 m<sup>3</sup>/hr with a peak of 20000m<sup>3</sup>/hr at day hours. Domestic waste loads, on the one hand, add a great burden on the pollution of the Tigris. These wastes comprise foul wastes of more than 6000 dwellings and apartments lacking waste collection system. Considerable amounts of these wastes are directly or indirectly (via valleys) discharge their loads into the river (table 3)

**Table 3:** Residential Units Distribution

Site	No. of Units	Location Relative to the River
Al- khadra	2535	Left
Sugar Mill	405	Right
Teztile Mill	1711	Right
Domeez	800	Left
Prefabricated Building	206	Left
Al- Yarmook	404	Right
AL- Mamoon	100	Right

The field survey reveals that some of the pollution sources are direct point sources while some other sources are indirectly affecting the river water quality. As these sources differ, the nature of their pollution loads vary accordingly as shown in tables (4-6). The characteristics of discharged wastewater can be grouped into the medium- strong categories according to guidelines [8]. The tests also verify that a clear deterioration in water quality does occur. Concentration of various contaminants & compounds exceed the limits recommended by local and authorized agencies [9, 10].

Odor, foam, color, death and migration of aquatic life, and dominance of anaerobic conditions can easily be detected near sewer outfalls. These adverse consequences as well as the increase of pollutant concentrations have lessen the river aesthetics, increase hardness, salinity, and rendering the water unfit for different beneficial uses.

**Table 4:** Characteristics of Domestic Wastes

Character	Domestic	Al-khosar	Character	Domestic	A-khsarl
pH	6.99- 7.41 (7.31)	7.32- 7.91 (7.53)	Cl	26-98 (55.3)	45-56 (49)
EC	647- 1043 (736)	880- 1043 (943)	SO <sub>4</sub>	190- 370 (233)	60-375 (167)
TS	400- 859 (667)	726- 1880 (997)	PO <sub>4</sub>	1.1- 10.5 (7.4)	2.18- 39 (12.5)
SS	110-460 ( 175)	60-120 (61)	NO <sub>3</sub>	0.37-1.8 (0.91)	0.4- 1.05 (0.69)
Alk.	140-240 (214)	200-265 (232)	BOD	56- 130 (69)	65-150 (72)
TH	270-520 (387)	440- 660 (520)	COD	103- 190 (124)	84- 247 (135)

**Table 5:** Characteristics of Industrial Wastes

<i>Character</i>	<i>Food</i>	<i>Textiles</i>	<i>Character</i>	<i>Food</i>	<i>Textiles</i>
pH	7.24- 9.44 (7.76)	6.9- 7.63 (7.19)	Cl	34-114 (45.6)	30-102 (52)
EC	500- 722 (584)	462-642 (522)	SO <sub>4</sub>	62-320 (136)	70- 173 (103)
TS	435- 1298 (851)	322-780 (531)	PO <sub>4</sub>	0.2-0.3 (0.21)	1-1.15 (1.01)
SS	50-152 (73)	82-240 (120)	NO <sub>3</sub>	0.9- 1.39 (1.01)	0.8- 3.2 (1.22)
Alk.	75- 340 (166)	145-500 (236)	BOD	81-848 (588)	100-190 (135)
TH	115- 340 (249)	190-420 (277)	COD	90- 1123 (409)	185- 410 (235)

- All units are in mg/l except pH .EC in micromhos/cm, TH, and Alkalinity in mg/l as CaCO<sub>3</sub>.
- Values between brackets represent the mean value

**Table 6:** Characteristics of Valleys Wastes

<i>Character</i>	<i>Eqab Valley</i>	<i>Danfeely Valley</i>	<i>Character</i>	<i>Eqab Valley</i>	<i>Danfeely Valley</i>
pH	7.24-7071 (7.35)	7.3-7.8 (7.51)	Cl	31-65 (36.8)	34-42 (37.8)
EC	570- 689 (630)	636- 802 (735)	SO <sub>4</sub>	40-260 (175)	80-250 (140)
TS	482- 2400 (839)	522-860 (697)	PO <sub>4</sub>	2.6-4.8 (4.05)	2.5- 8.4 (5.37)
SS	58- 600 (180)	89- 260 (131)	NO <sub>3</sub>	0.27- 1.50 (0.59)	0.9-1.5 (1.06)
Alk.	160- 200 (176)	170- 260 (215)	BOD	43-110 (56.6)	30-106 (55.1)
TH	272- 300 (288)	348- 500 (383)	COD	54-153 (99.3)	70-152 (112.8)

The changes in the physical characteristics of the river water such as temperature, turbidity, and suspended solids are clearly demonstrated in table 7. These changes are detected as the river passes along the stretch of the study area. In the north of the city there exists a large water impoundment. Some quarries and constructional mills are encountered. Animal breeding (buffalo, sheep and cows) are widespread. In the heart of the city there are more than 15 point sources discharging their loads into the river. It is strongly stressed that such activities will continue deteriorating the river water quality.

**Table 7:** Major Human Activities Affecting the Physical Characteristics of the River

<i>Activity</i>	<i>Temperature</i>	<i>Turbidity</i>	<i>Suspended Solids</i>
Cooling Processes	++		
Domestic Sewage Discharges	+	+	+
Industrial Wastewater Discharges	+	++	++
Agricultural Activities	+	+++	+++
Navigation		++	++
Dredging		++	++

+ Slight Increase; ++ Clear Increase; +++ Severe Increase.

One of the most important sources of pollution is the domestic discharges. Such wastes render the river water unfit for beneficial uses. Previous studies [11] revealed that the river water is no longer valid for swimming. The total bacterial count in the discharged wastewater is amounted as high as  $2 \times 10^4 - 2 \times 10^7$ . These amounts exceed the recommended values [12]. This disorder is attributed to some illegal practices such as discharging toilet waste directly into the river or due to in-house slaughtering activities.

Eutrophication, a phenomenon that largely takes place at lakes and slow moving water bodies has found an access to occur in the Tigris. This problem arises from the fact of using large amounts of nutrient- rich detergents. Throughout the past years, detergents were distributed to the families as a part of a monthly ration of oil for food program during sanction (1991-present). Such detergents contained high concentrations of phosphorous the main cause of eutrophication, (see table 8).

**Table 8:** Components of Used Detergents as a Part of Family Ration.

<i>Component</i>	<i>Percentage</i>
Active Ingredients	24 %
Multisodium Phosphates	30 %
Sodium Silicates	8 %
Sodium Sulphates	26 %
Perfumes	(0.1 – 0.3) %

Moreover, eutrophication can be detected by chlorophyll measurement which surpasses the guidelines of 2mg/l [13]. Eutrophication is known of its vast adverse effects, some of which are listed in table (9). The BOD<sub>5</sub> values represent the organic pollution of the Tigris. Organic load leads to decline of dissolved Oxygen and release of ammonia and nitrite. This declination may extend for tens of kilometers.

**Table 9:** Some Problems Caused by Eutrophication

Economic loss due to tourism decline and polluted river water	Increase in heavy metal concentration
Fluctuation of dissolved oxygen concentration during day and night	Increase of chlorination doses that may cause cancer
Turbidity increase	Disturbance of flocculation process
Increase of bacterial growth	Corrosion of pipes, reservoirs and facilities
Clogging of filters in water treatment plants	Odor, color, and taste
Water Intakes clogging	Variation of pH

Table (10) illustrates BOD variations along the studied stretch. This table indicates that river water can be classified as poor- good in terms of quality as per authorized standards [14]. It does show that the Tigris starts recovering its health after 40km.

**Table 10:** BOD<sub>5</sub> Variation along the Studied Stretch

Site	Distance km*	Concentration mg/l	Remarks
Unified WTP	0.00	2.7	River entrance to Mosul city
Bridge 3	8.0	3.3	Industrial activities predominate. A valley discharges its load of domestic & industrial pollutants directly into the Tigris
Bridge 4	11	3.2	Human & man-made activities through 20 outfalls appear to affect the river quality in this location
Albosaif	18	34	Very polluted valleys and other main box sewer as well as sugar mill & tanneries discharge their load of pollution in this stretch.
Qunetra	34	3.00	The river starts self purification and recovers its aesthetics.

\* Reference Point

On the other hand, the survey revealed the huge adverse impacts incurred by industry, tourism and health-care institutions. Most of local industries have no wastewater treatment plants. Wastes are directly discharged untreated into the Tigris. Most of existing wastewater treatment plants do not perform as expected. Moreover, such plants are secondary and incapable of removing nutrients (P&N compounds) as well as they poorly perform at shock loads occasions. Table (11) shows the performance of some plant covered by the survey.

**Table 11:** Wastewater Treatment Plants Performance

Plant Site	Effluent SS (mg/L)	% Removal	Effluent BOD (mg/L)	% Removal
Neneva Hotel	17- 200	12- 66	30 –93	5-63
Khansa Hospital	22- 65	13- 87	23-150	14-62
Al-Salam Hospital	23-91	40-96	6-24	75-90
Mosul Hotel	80-112	11-23	10-30	50-90
Hospital Complex	38-200	33-72	11-22	76-90
Food Industries	50-500	3-50	36-220	30-66

Heavy metals such as chrome, copper, and arsenic may have an access to reach the river. Some industries produce these elements in their processes like textiles industries, tanneries, etc. Al –Layla & Al-Rawi confirm this fact upon studying impact of textile wastewater discharges on the Tigris [15]. Lead concentrations may increase in the river water. This element arises from traffic and reaches the river from runoff or via atmosphere. The problem with heavy metal is that they are absorbed by particulates at normal pH levels causing very low dissolved traces and consequently its monitoring becomes very complicated [16].

**Conclusions**

- (1) The Tigris river water quality shows a distinct deterioration within the studied stretch . Point and non- point sources of pollution are widespread along the selected stretch.
- (2) Domestic wastewater discharges and illegal practices severely affect the Tigris water quality. This is reflected on an increase in organic & bacterial loads, and causing health risks.
- (3) Industrial, tourism, medical institutions and other services add to the pollution of the river impeding self purification and rendering the water unfit for different uses.
- (4) Reduced performance of waste treatment plants accompanied by the lack of specialized operators.
- (5) The increased consumption of detergents increased occurrence of eutrophication.

- (6) The Tigris starts recovering health and resumes an acceptable quality after 40 km from reference point.
- (7) Absence of awareness of the pollution prevention measures and the non-existing of a real environmental monitoring authority increased pollution of the Tigris.

### Recommendations

- (1) Water and sewerage directorates should play an effective role in preventing unlawful connections to water networks and reducing hydraulic loads received by the river.
- (2) Environmental authority should be given the power to enforce the law against illegal practices.
- (3) All types of media should contribute to raise the public awareness of environmental protection as a holy and human task recommended by all religions (Islam, Christianity, etc).

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