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Assessment of Water Quality of House Water Using Water Pollution Index in Mosul City

Shaimaa abd elkader Naser1, Moath Abdullah Al- Hajjar2
1. Department of Chemistry, College of Science, Mosul University, Mosul, Iraq. Shaimaa76216@gmail.com,
2. Department of Soil Science, College of Agriculture and Forestry, Mosul University, Mosul, Iraq.
moathalhajjar@uomosul.edu.iq

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Corresponding author:
Name: Shaimaa abd elkader Naser
Affiliation: Mosul University
Email: Shaimaa76216@gmail.com

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A B S T R A C T

The current study included an assessment of the pollution index (WPI) for house waste water collected in five sites in Mosul city, depending on some physical and chemical analyzes of twelve samples of water from these sites distributed on both sides of the right and left in Mosul city for seven months, starting from August 2022 until February of 2023, which was collected a sample from each month and analyzed in a laboratory to evaluate the characteristics of this water, For Chemical Oxygen demand, Biological Oxygen demand, sodium, Phosphates, sulfates, nitrates, chlorides, turbidity PH, magnesium, calcium. The results indicated that the values of the water pollution Index (WPI) were between (1.0-2.0) in sites 1, 3, 4, and 5. Thus, the water of the studied sites is of Moderately polluted (III), suitable effect casting in the river, while WPI values are in Location 2 was less than 1.0 of pure type (II).

Introduction

The problem of pollution has become one of the sensitive issues in the world facing man and the environment, especially after the development accompanying contemporary life and economic development that the world is witnessing today, pollution occurs in its various forms, whether it is air, water or soil pollution due to an increase or decrease in the proportions of some basic components in the environment than its natural proportions, and since water is the main component of life and its multiple uses in agricultural and industrial activities that need huge amounts of water, adding any extraneous substance From chemicals, bacterial, or radioactive substances to different aquatic ecosystems, there will be a direct or indirect change in the physical, chemical and biological properties of water that negatively affects living organisms [1, 2].

Where the water crisis has turned into a global crisis due to climate change, water scarcity, and recent industrial, economic and social developments [3], statistics indicated that water consumption in the twentieth century doubled in the period between (1990-1995) six times, equivalent to more than double the rate of population growth, and a third of the world's population will face in 2025 serious water crises due to the increasing need for water due to the increase in the world's population and the accompanying The development of agricultural and industrial activities that lead to pollution of water sources and an imbalance in the natural balance of the environment [4], and irreversibly changing aquatic ecosystems causing a danger to plants and animals, including humans, as civil and industrial waste contains huge numbers of aerobic and anaerobic microorganisms, and large quantities of organic and inorganic substances complex in composition that are non-biodegradable when discharged to rivers and are thus considered carcinogens, and dangerous to humans and animals [5, 6].

Excessive discharge of nitrates and phosphates is the most prevalent in the water system resulting from washing powders and the decomposition of organic materials and from various industries, which causes eutrophication (the phenomenon of food enrichment), which leads to serious threats to the health of people, aquatic organisms and plants[7], and for this it was necessary to manage and follow up water resources (surface and groundwater) efficiently and well and reduce sources of pollution with the continuation of studies and research to evaluate physical and chemical properties and compare them with global determinants. As well as the selection of the necessary measures and plans in dealing with water resources that enhance the elements of providing and maintaining estuaries from pollution [8], where many indicators have been developed by determining water quality in the most common form to analyze water properties and detect different pollution levels, which is a new and modern technique compared to previous indicators, and depends mainly on the observed concentration Ci in some researches symbolized by Ai and on the permissible standard concentration Si or Ti [9], as WPI is an important tool to summarize the file of a large number of water quality data into one value, which helps the researcher Or an expert in determining the extent of pollution and working to find appropriate solutions in conserving, reducing and reusing water [10].

Many Arab and international studies have been conducted on the WPI water pollution index, where a study carried out by [11] measured and analyzed nine physical and chemical water quality criteria to calculate the WPI for the Shatt al-Basra canal located in Basra Governorate, Iraq and the study showed that the canal water is of the polluted type, highly polluted and unfit for drinking or human use. Another study carried out by [12] in the WPI calculation of bottled and groundwater sources in some parts of the Ghana region and the method showed that WPI is flexible and easy to calculate method compared to the water quality index WQI, and a study was also conducted by [13] in the analysis of temperature and pH according to the WPI water pollution index standard in the Dumas area near Tapi and it was noted that the nature of the polluted water in an estuarine environment The rivers were light to highly polluted according to WPI due to human activities as well as industrial, commercial and others.

Materials and methods

Water sample collection:

For water parameter analysis, water samples were collected for laboratory measurements using clean glass bottles washed with well-distilled water with a capacity of 1000 mL, while samples related to the estimation of the biological requirement of oxygen BOD5 were used to collect special bottles of 500 ml without causing air bubbles as much as possible, refrigerated boxes away from light for the purpose of preserving samples until reaching the laboratory, how much was the site address, date of taking the sample and weather condition [14, 15], where image (1) represents the five GPS sampling sites for Google Erath, and Table (1) shows the characteristics and latitude and longitude of the sample locations.

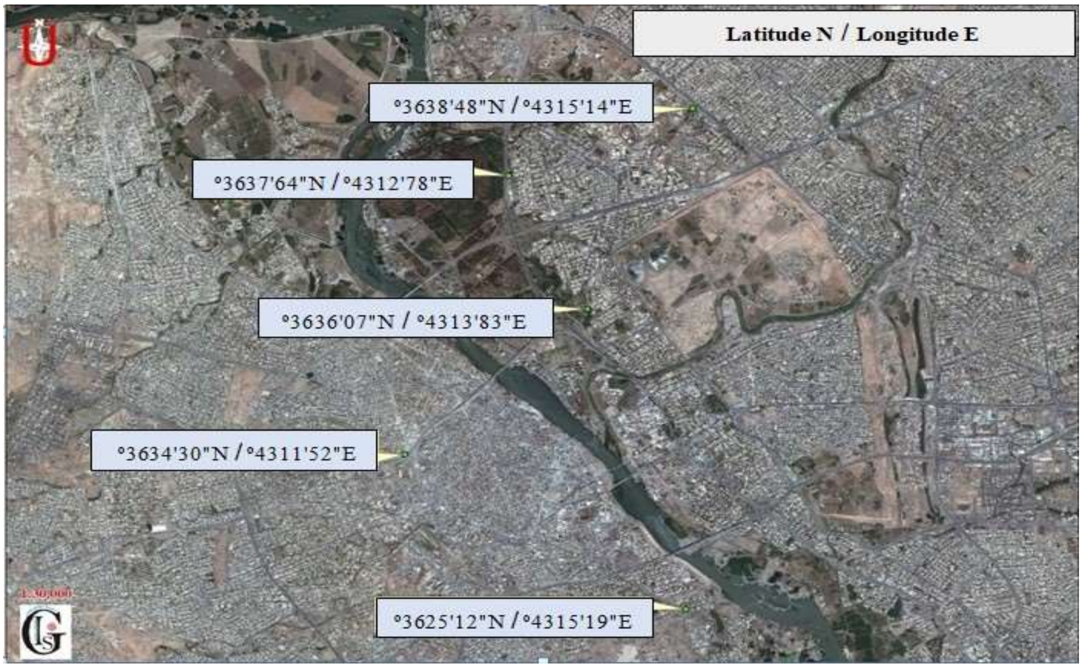

Image 1. A satellite image of the sample collection sites for the study area

Table 1. The longitude and latitude values

Locations of station	Latitude N	Longitude E	Actual Energy (M3/hr)
1	Nº3636'07"	Eº4313'83"	8700
2	Nº3637'64"	Eº4312'78"	5200
3	Nº3638'48"	Eº4315'14"	3900
4	Nº3634'30"	Eº4311'52"	2900
5	Nº3625'12"	Eº4315'19"	6000

These sites included five areas for the collection of water and household and rainwater in the city of Mosul distributed on the right and left side of the city as follows:

Site (1) Al-Kharrazi Lifting Station: It includes areas of neighborhoods (Mohandessin, Al-Wazir, Al-Zara'i neighborhood, Nerkal, part of Al-Sukkar neighborhood) and the station pours its water into Wadi Al-Kharrazi and then into the river.
Site (2) Al-Sukkar Lifting Station: This station includes areas of neighborhoods (Al-Sukkar, cultural group, Andalusia neighborhood) and the station pours its water into Al-Kharrazi station first, then to Wadi Al-Kharrazi and then to the river.
Site (3) Al-Hadba Lifting Station: It includes the areas of neighborhoods (Al-Hadba, Al-Kafaat, Al-Sukkar, Al-Siddiq, Al-Baladiyat), whose water also flows into Wadi Al-Kharrazi and then into the river.
Site (4) Bab Sinjar Lift Station: It includes areas of neighborhoods (Al-Thawra neighborhood, Al-Zanjili, Al-Bursa, Bab Sinjar) whose water flows directly into the river.
Site (5) Al-Boxy Lifting Station: It includes the neighborhoods of (Al-Dawasa, Al-Josaq, Al-Dandan, Al-Tayaran, Bab Al-Jadeed, Wadi Hajar, Al-Tawafa) whose water flows directly into the river.

Chemical and physical tests of water samples:

Standard methods were followed in the analysis of the current study samples in the laboratories of the Nineveh sewers [15] and were compared with the Iraqi specifications for the maintenance of rivers from pollution [16], which included tests including turbidity, pH, phosphate ions, sulfates, nitrates, the biological requirement for oxygen, the chemical requirement of oxygen, sodium, calcium, magnesium, and chloride.

Calculation of the WPI Water Pollution Index:

The water pollution coefficient was calculated to determine the extent of pollution indicated by many researchers [13] and according to the following:

$$\text{WPI} = \frac{1}{n} * \sum_{i=1}^{n} \frac{Ai}{Ti} \quad \text{-----------} \ (1)$$

WPI: water pollution index.
A_i : average transaction values.
T_i: permissible standard limits.
n: The total number of transactions [13, 17].

Table 2. Water quality classification according to WPI [13]

Class	Characteristics	WPI
I	very pure	=< 0.3
II	pure	0.3 – 1.0
III	Moderately polluted	2.0 – 1.0
IV	polluted	4.0 – 2.0
V	impure	6.0 – 4.0
VI	Heavily impure	> 0.6

Results and conclusions:

Physical and chemical properties:

Turbidity is an indicator of the presence of pollution and is one of the physical characteristics that determine the validity and quality of diverse water resources in nature Water turbidity is due to the presence of living and non-living suspended matter, which absorbs and scatter light with scattered lines instead of moving it in a straight line through the model in the examination devices [18], where the rates of turbidity values ranged from (17.8-91.1) NTU as shown in Table (3), the reason for this increase is due to Discharge of sewage rich in suspended matter, effluent, mud, silt, organic and inorganic matter into the stream [19, 20].

The pH function is a mean of expressing the activity and concentration of hydrogen ions in water and is one of the chemical criteria that have a direct impact on human health [21], the results of the study shown in Table (3) indicate that the values of pH rates reached (7.13-7.42), and it is noted that the water of the studied areas was close to the neutralization state and within the normal range despite the high salinity values in the studied areas, as it was considered within the water classification of normal effect [22].

The rates of both the biological requirement of oxygen BOD and the chemical requirement of oxygen COD ranged between (31.6-96.8) and (49.1-155.7) mg. L^{-1} respectively as shown in Table (3), the results of the values of these parameters have exceeded the permissible limit according to the Iraqi determinants that set a limit for the highest concentration of the biological oxygen requirement and the chemical requirement for oxygen (40, 100) mg. L^{-1} respectively, and this increase is due to the huge amount of organic waste in the sewage discharged to the valley, then the occurrence of anaerobic decomposition processes and the release of gases (H2S, NH3) with the emission of unpleasant and annoying odors [23], as well as the presence of bacteria and microorganisms that work to decompose organic matter in water within five days under suitable aerobic conditions of temperature and during a specific period of time, which leads to the consumption of dissolved oxygen [24].

The presence of excess suspended matter harms the health of the water body and thus affects public life, and the discharge of suspended materials sedimentable into water leads to increased sedimentation rates and often destroys aquatic systems and organisms as well as reduced metabolic processes [25, 26], and the average values of solid suspended matter ranged between (34.5-107.4) mg. L^{-1} as shown in Table (3).

Phosphorus is also one of the important and necessary elements that the plant needs to complete its life cycle, as it is included in the synthesis of ATP adenosine triphosphate, which is an energy carrier [27], where its rates ranged in the range of (2.28-7.1) mg. L^{-1} As shown in Table 3, the reason for the high concentration of phosphate in greywater is due to the use of cleaning products containing high levels of phosphorus compounds containing the tri polyphosphate ion, which reacts with water to form phosphate ions $PO4^{-3}$ and to agricultural fertilizers [28].

As for the average nitrate values as shown in Table (3), low values of nitrate concentration NO_3 were recorded in most sites ranging between (3.2-4.8) mg. L^{-1} was well below the Iraqi river pollution limit, which set a limit of up to 50 mg. L^{-1}[16].

Sulfate ions are one of the most prevalent compounds in natural waters, and they are negative anions that cause permanent hardness in water when present with calcium and magnesium, which cause water salinity [29], where the results indicated their rate values in the range of (49.9-218) mg. L^{-1} was within the normal limits of subtraction into the river [25].

Chloride is one of the indicators of water salinity and is one of the important negative ions found in natural water, which gives water a salty taste if it is associated with sodium ion [30], where the values ranged from (40.2-67.1) mg. L^{-1}, generally there is no problem with chloride toxicity when using the water of the studied areas for irrigation because all values are within the permissible limits for irrigation.

Water containing high concentrations of calcium and magnesium gives the water an unacceptable taste, which causes kidney problems, stone formation and arthritis, and the presence of high concentrations of sulfates with magnesium causes severe diarrhea [31], where the values of their rates are between (48-96.5), (28.2-53.5) mg. L^{-1} respectively, and calcium hardness rates were higher than magnesium hardness rates for most of the sites studied.

The sodium ion is found in natural water at higher concentrations than potassium ion concentration, as water in which the concentration of potassium on sodium is considered abnormal [32], with values of (19.9-40.3) mg. L^{-1}, where the values of the current study exceeded the permissible limit of 35 mg. L^{-1} in some locations, as the concentration of Na increases due to geographical factors and the discharge of sewage, waste, etc., and this is confirmed by some studies, including the study [33].

Table 3. Average values of physical and chemical properties. **(*)**[16, 25]

Parameters	Standard Ti*	Site 1	Site 2	Site 3	Site 4	Site 5
		Ai	Ai	Ai	Ai	Ai
pH	8.5	7.18	7.3	7.42	7.26	7.32
Cl (mg. L-1)	600	47.5	40.2	52.2	67.1	45.4
Turbidity (NTU)	10	50.5	17.8	91.1	57.4	58.6
COD (mg. L-1)	100	61	102	155.7	95.5	49.1
BOD (mg. L-1)	40	41.4	33	96.8	59.4	31.6
TSS (mg. L-1)	60	99.7	34.5	107.4	84	78
NO3 (mg. L-1)	50	4.4	5.3	4.15	3.41	3.97
PO4 (mg. L-1)	3	3.39	2.28	6.02	7.1	5.18
SO4 (mg. L-1)	400	218	66	94.9	137.8	107.5
Mg (mg. L-1)	50	53.3	29.9	32.2	33.4	28.2
Ca (mg. L-1)	200	96.5	48	52.5	69.4	62
Na (mg. L-1)	35	30.7	19.9	31.6	40.3	21.1

WPI Water Pollution Index

The results showed that the values of $1.0 < WPI$ for sites 1, 3, 4, 5 of the type (III) Moderately Polluted and according to the international classifications of water pollution coefficient WPI as shown in tables (4), (2) and Figure (1) and there is no risk in the release of water to the aquatic environment, either site 2 was of the type (II) Pure any pure and good water, and the results of the studied sites were less than the results obtained by [13] in their study of a tropical environment, where the WPI values in the first year were between (1.23-7.8), while in the second year they reached (1.7-6.3), and less than the results obtained [11] when they studied to assess water quality using the WPI model for the Shatt Al-Basra channel located in Basra Governorate, where the WPI values were about (9.7-17.3) and they were of the type IV, which is considered highly polluted, dangerous and toxic to the aquatic environment in the channel.

Table (4): Average concentration ratio and water quality class parameters WPI for the analyzed parameters.

(*)[16, 25]

Parameters	Standard Ti*	Site 1 Ai/Ti	Site 2 Ai/Ti	Site 3 Ai/Ti	Site 4 Ai/Ti	Site 5 Ai/Ti
pH	8.5	0.84	0.86	0.87	0.85	0.86
Cl (mg. L-1)	600	0.08	0.07	0.09	0.11	0.08
turbidity (NTU)	10	5.05	1.78	9.11	5.74	5.86
COD (mg. L-1)	100	0.61	1.02	1.56	0.96	0.49
BOD (mg. L-1)	40	1.04	0.83	2.42	1.49	0.79
TSS (mg. L-1)	60	1.66	0.58	1.79	1.40	1.30
NO3 (mg. L-1)	50	0.09	0.11	0.08	0.07	0.08
PO4 (mg. L-1)	3	1.13	0.76	2.01	2.37	1.73
SO4 (mg. L-1)	400	0.55	0.17	0.24	0.34	0.27
Mg (mg. L-1)	50	1.07	0.60	0.64	0.67	0.56
Ca (mg. L-1)	200	0.48	0.24	0.26	0.35	0.31
Na (mg. L-1)	35	0.88	0.57	0.90	1.15	0.60
WPI=∑ Ai/Ti*1/n	….	1.12	0.63	1.66	1.29	1.07
Characteristics/ Class	….	Moderately polluted III	Pure II	Moderately polluted III	Moderately polluted III	Moderately polluted III

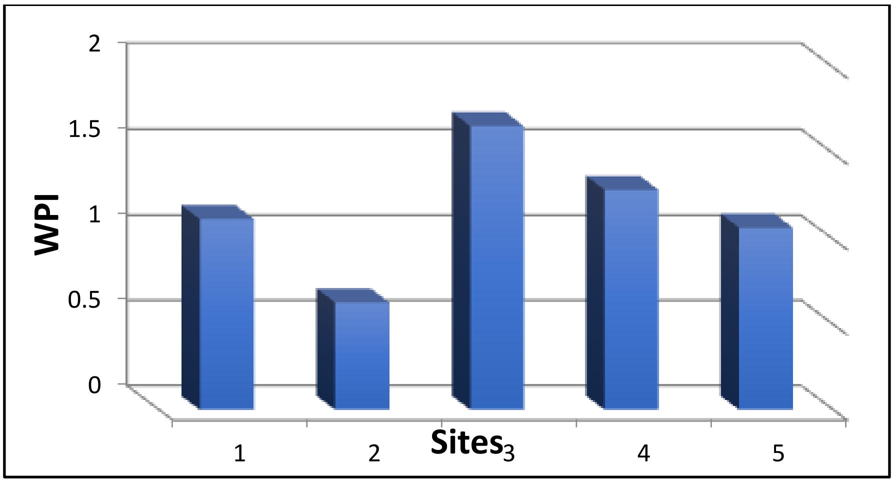

Figure (1) WPI values for pollution

Recommendations:

1. This study recommend reducing the release of domestic and industrial waste and taking advantage of low-lying areas to transport sewage through a box stream so that water can be treated naturally and autonomously.
2. Conducting research and studies using modern techniques to show the effect of bacterial contamination, especially fecal coliform bacteria, which are considered one of the most dangerous types of bacteria.
3. Applying modern indicators and techniques, including the WPI water pollution index, to determine water quality, which of them is more suitable for irrigation and pollution according to the Iraqi water determinants.
4. Strengthening and expanding the work of chemical and biological laboratories for monitoring water pollution.

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