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Environmental Geochemistry of the Euphrates River from Al-Qaim to Basra Governate, Iraq: Articles Review

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ABSTRACT

The Euphrates River is one of the longest rivers in West Asia. Its length is 2786 km. The river basin has an area of 440,000 km². It enters Iraq, north of Huseiba on the Iraqi-Syrian borders, and cuts through carbonate bedrock forming a very slim strip flood plain. This study describes and explains the hydrochemistry, water quality, water plus sediment pollution assessments, and sediment geochemistry of the Euphrates River within Iraq by reviewing several environmental, geochemical, and environmental pollutants in previous papers.

The water chemistry of the Euphrates River revealed good and clear results during the years 2012 and 2016 and it was characterized by dominant SO4 and Cl ions in 2013, although the water chemistry altered through the year 2021. The high temperatures and the absence of rainfall contributed to the deposition of large quantities of gypsum on the river bed, which caused the depletion of $SO4^{-2}$ in the river water. By way, the sequential of the salt's precipitation and ions solubility was increased.

From 1995 to 2020, it is clear that there are increasing concentrations of toxic trace elements in sediment such as Cu, Ni, Co, and Cd. The content of these elements in the Euphrates River sediments increased towards Basra City with an increase in water salinity due to the climatic changes that occurred in recent years and the desertification of the region. Also, agricultural and industrial activities, domestic wastewater discharge, and irregular continuing human consumption of the river water had the greatest role in causing pollution.

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الجيوكيمياء البيئية لنهر الفرات من القائم الى محافظة البصرة، العراق

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الملخص

يعد نهر الفرات أحد أطول الأنهار في غرب آسيا، اذ يبلغ طوله حوالي 2786 كم، كما تبلغ مساحة حوض النهر 440 ألف كيلومتر مربع. يدخل العراق على بعد بضع كيلومترات شمال الحصيبة من جهة الحدود العراقية السورية، ويمر عبر صخور كاربونية مكونًا شريطًا ضيقا في سهل الفيضان. تشرح الدراسة الحالية الهيدروكيمياء وتصفها وتتطرق ايضا الى جودة وتقييمات المياه فضلا عن تلوث الرواسب وجيوكيمياء رواسب نهر الفرات داخل العراق من خلال مراجعة العديد من بحوث الجيوكيمياء والبيئة. كشفت كيميائية مياه الفرات عن نتائج جيدة وواضحة خلال عامي 2012 و2016 وتميزت بان $SO4^{-2}$ و Cl في 2013 هي الأيونات السائدة، على الرغم من أن كيميائية المياه تغيرت خلال عام 2021. ان ارتفاع درجة الحرارة وغياب الأمطار قد ساهمت في ترسب كميات ضخمة من الجبس على مجرى النهر وهذه الحالة استنفدت SO4 في مياه النهر ، عن طريق تسلسل ترسيب الاملاح وزيادة ذوبان الأيونات.

اوضحت الفترة من عام 1995 إلى 2020، أن هناك تراكيز متزايدة من العناصر النزرة السامة في الرواسب مثل النحاس والنيكل والكربون والكادميوم. وازداد محتوى هذه العناصر في رواسب نهر الفرات باتجاه مدينة البصرة مع تزايد ملوحة المياه بسبب التغيرات المناخية التي حدثت في السنوات الأخيرة وتصحر المنطقة. كان للأنشطة الزراعية والصناعية للسكان والاستهلاك البشري المستمر غير المنتظم لمياه الأنهار الدور الأكبر في التسبب في التلوث.

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Introduction

The Euphrates is the longest, most factually significant river in Western Asia. It is one of the two important rivers in Mesopotamia (Coad, 1996), where 40% of its distance (1213 km) lies in Iraq (Hassan and Al-Bassam, 2006). From Turkey, the Euphrates River moves toward Syria and then to Iraq. It joins the Tigris River by the side of Shatt al-Arab, which discharges into the Arabian Gulf (Geopolicity, 2010). Once the Euphrates arrives at the topmost of the Mesopotamian plains, its position droplets pointedly; inside Syria; Euphrates drops 163 m, while over the last in the middle of Hit then to the Shatt al-Arab, the river drips objective 55 m (Hartmann, 2010). Mean values discharged at Hit after 1990 released to 356 m^3 for each second (11.2 km^2, 2.7 mil^2) each year. Periodic charge ability has been altered (Wilkinson, 2006).

So; in Turkey, The Euphrates River flows through the Anatolide-Turoside Block in Erzurum Plateau, intercepting Northern and Eastern Anatolian faults, and then enters the Bitlis-Zagros Suture Region. In Syria, it is interested in the Aleppo Plateau, which is a part of the Arabian Plate. Also, it is affected by the Irbid Rift besides the Palmyrides (Kalender and Aytimur, 2021). The Euphrates River flows beforehand toward inside Iraq and currents into Azraq Graben, which is the continuance of Ana Graben in Iraq. The larger share of the Euphrates River basin is situated in Turkey, Syria, as well as Iraq; referring to the direction of Daoudy and Frenken, a portion of Turkey is 28 percent, Syria's is 17 percent, and Iraq's is 40 percent (Karen, 2009).

The Euphrates Holocene sediments contain primarily unconsolidated to fairly well-indurated deposits of sands, silts, and clay. The deposits of pebbles exist in particular upstream parts. The water level of the Euphrates River in Iraq is low for the reason that irrigated uses nominated in Turkey and Syria are discharged into the river. Chemicals from dissolved fertilizers are used in green spaces. The total dissolved solids of Euphrates water in Iraq is greater than before due to the upstream dam structure. This leads to less fitness for drinking water. Several dams, irrigation schemes, and the accompanying significant water construction must also have a harmful influence on the environmentally insubstantial marshes of Mesopotamia and the fish habitats of Iraqi freshwater (Juris, 1997). Even though the greater portion of the Euphrates basin is set in the interior Stable Shelf, on the other hand, many signs exist in the basin that observes the Neotectonic Geology of the Euphrates through an emphasis on the Iraqi Shared 175 actions (Sissakian et al., 2017). In general, the high concentration of phosphates and nitrates in the Euphrates River in the Al-Qaim region showed that the pollution is caused by molten waste formed during or after the co-establishment of phosphates in western Iraq (Al-Quwaizi, 1989).

In the assessment of the Tigris and Euphrates rivers, the Euphrates River has a comparatively higher ionic content than the water of the Tigris River. This is in line with many factors that use deference to total hardness (Al-Marsoumi, et al., 2006). Mustafa (2009) classified the Euphrates inside Ramadi City as appropriate for drinking, irrigation, and many different industrial purposes. Other environmental studies assessed the Euphrates River water and sediments in several Governorates, and their results are discussed below in the results and discussion article of the current work. The study deals with Euphrates water hydrochemistry to expose anthropogenic and natural pollution causes and their properties to the quality of Euphrates water and to estimate the water class for human consumption besides farming determinations.

Geological setting

The Euphrates passes into Iraq at Al-Qaim City and continues for more than 1000 km until Al-Qurna City, where it meets the Tigris River. It crosses various geological formations inside the stable shelf of the Iraqi Nubian–Arabian Craton (Jassim and Goff, 2006) (Fig. 1). Lithostratigraphically, the area which is passed by the river can be described as subsequent, outcropping formations that range in age from the Eocene to Quaternary deposits. The Euphrates Limestone Formation (Lower Miocene) can be seen adjacent in the direction of Wadi Al-Mehemdi. It has extensive experience, covering the direction of the southern and southwestern parts of the Mesopotamian plain until Fallujah. Its unconformable superimposes the Anah Formation. It mostly involves limestone. The Euphrates Formation is deposited underneath lagoons, shallow marine, reef environments, and through resident coral reefs (Buday, 1980).

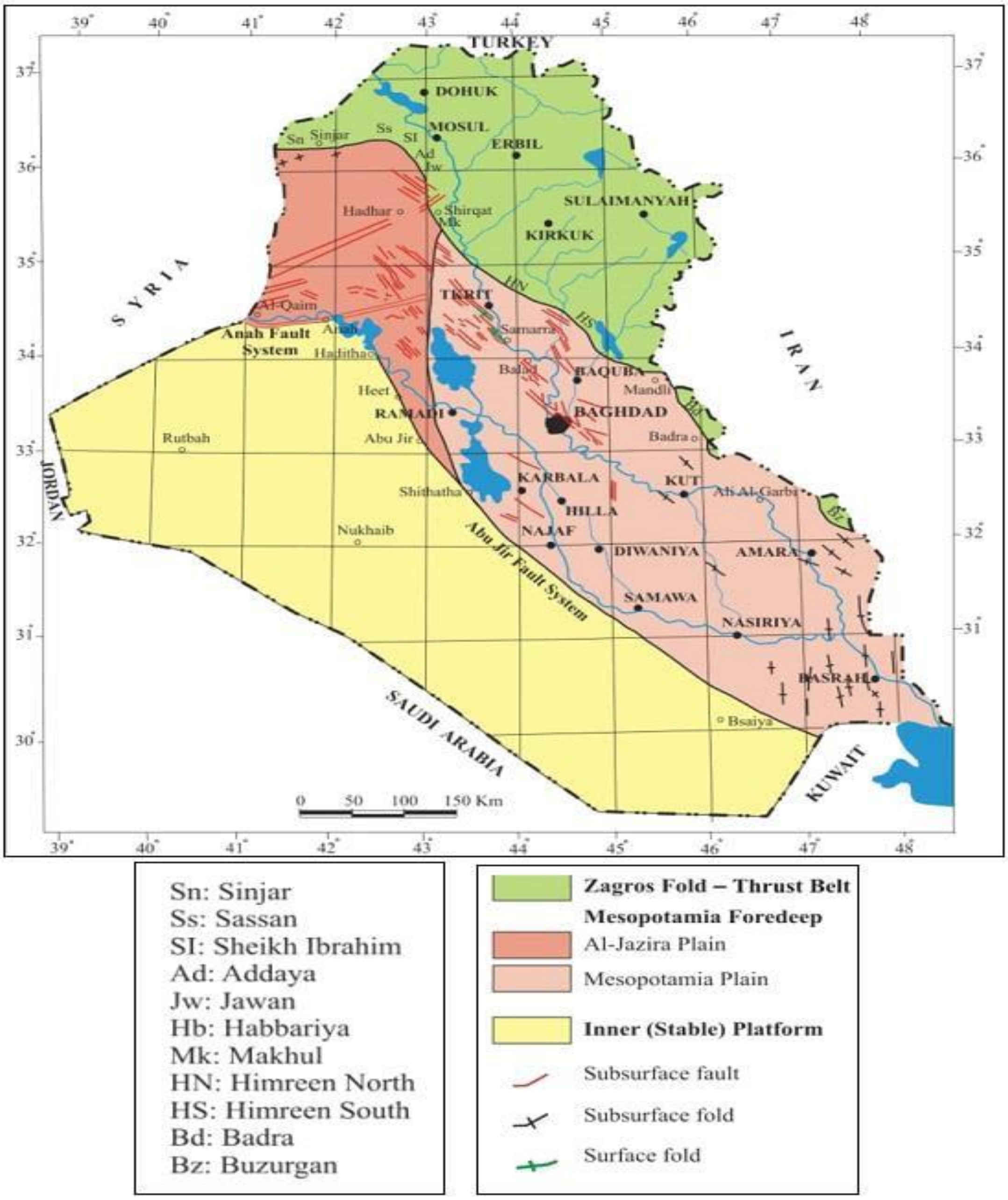

Fig. 1. Map of Mesopotamia Fore deep (After Fouad and Sissakian, 2011 and Sissakian et al., 2018)

The Euphrates Formation, which hosts the Euphrates River, increases Ca^{2+} in addition to carbonates (CO_3^{2-}) as a result of dissolution developments. The Fatha Formation (Middle Miocene), a lower connection with the Euphrates Formation, is conformable. This formation in the study area seems the upper end of the stratigraphic sequence, making Mesa. In addition, cuesta transforms closer to Hit City (Fig. 2) (Buday, 1980; Awadh and Ahmed, 2013). The formation thickness is generally variable. Significant portions of the basin's thickness may reach more than 900 m. However, the studied area around Hit is less than 15 m. It is the evaporitic facies, primarily comprising gypsum and anhydrite alternating with limestone and marl. The water is classified into two parts depending on the water chemistry; the upper part in the Iraqi western area is the first part, characterized by the sulfates–bicarbonates category; and the lower part in the Iraqi south is the second one, characterized by the sulfates–chlorides category (Banat and Al-Rawi, 1986).

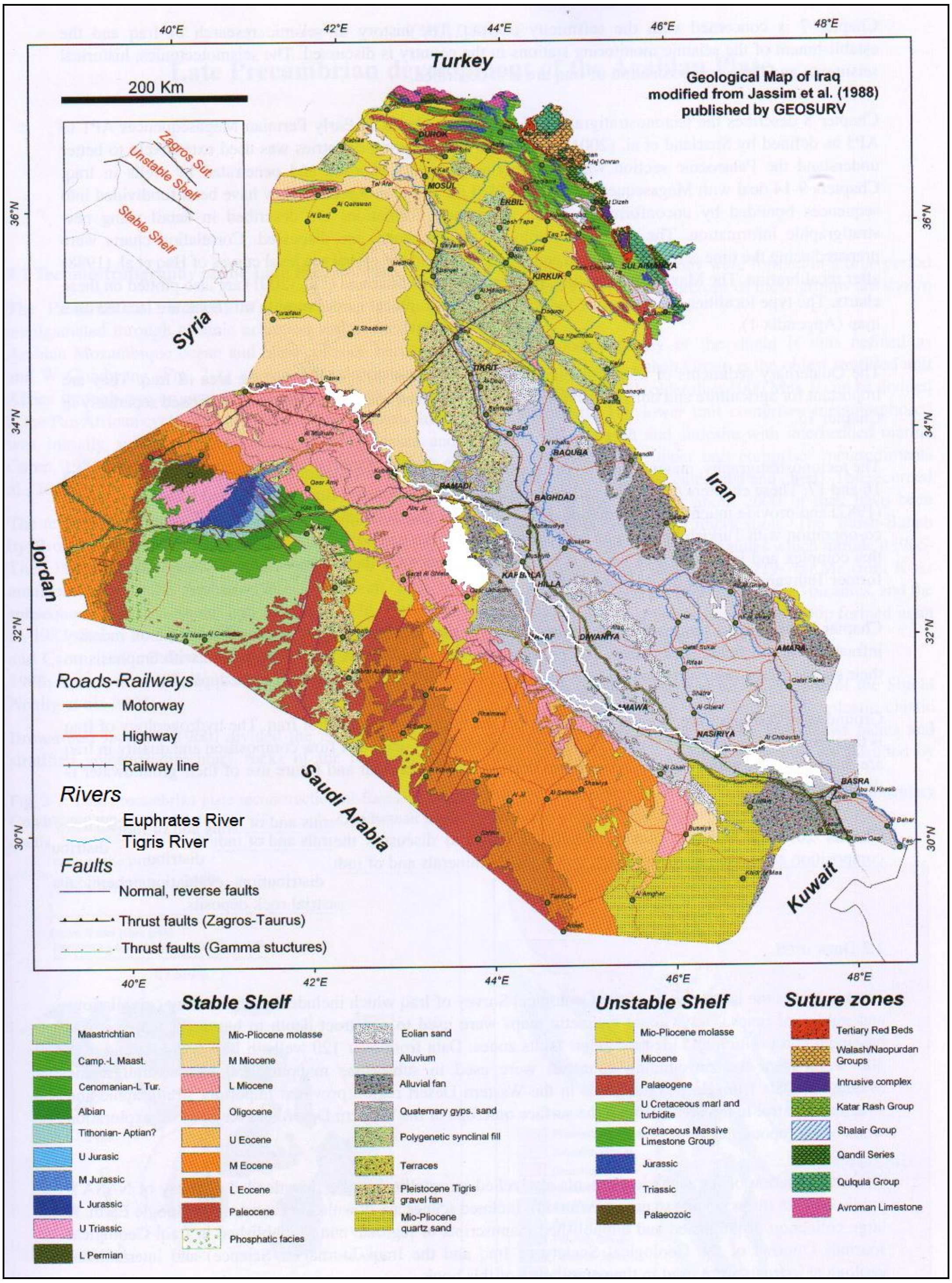

Fig. 2. Geological map (after GEOSURV Geological maps of Iraq) (Jassim and Goff, 2006)

Materials and Methods

To conduct an environmental geochemical study to evaluate pollution for any river or lake ecosystem, water, and sediment analysis must be conducted according to the following:

1. Fieldwork

Fieldwork for most previous studies is concentrated on studying the geological viewpoint, mainly lithostratigraphy, in addition to hydrological conditions to enable the task of understanding the environmental geochemistry of the Euphrates River. The assessment was of the various purposes of the study area to collect water as well as sediment. Information on the water and sediment numbers samples for each previous research and study and site coordinate have been mentioned in Table 1.

Table 1. Information on the water and sediments numbers samples, and site coordinates for important previous research and studies

Sample No.	Location & Study time	Water numbers samples	Sediments numbers samples	Coordination of study area	
				N	E
1	Hit to Al-Saqlawiya in Iraq, Western Iraq (2012)	27		33° 41' 53.9″	42° 45' 35.9 ″
				33° 22' 09.6	43° 37′ 14.5 ″
2	Haditha Dam and Site of Al-Baghdadi Dam (2013)	7		34° 15'24″	42° 24'12"
				33° 55'09″	42° 33'48″
3	From Al-Hindiya Barrage to Al-Nasiriya City, South Iraq (2016)	21	21	32°43'34"	44°16'01"
				31°01'48"	46°17'56.8"
4	Along the Euphrates Rivers (2021)	17		34°23'47"	41°04'14"
				31°00'16"	47°26'18"
5	Al-Samawa City (2021)	6		31°19'48"	45°14'47"
				31°18'58"	45°18'57"
6	South Al-Hindiya Barrage to Nasiriya City (1995)		21	32°43'35"	44°16'21"
				31°02'08"	46°15'56"
7	Hit to Al-Saqlawiya (2011)		19	33° 42′ 57.3″	42°45′ 17.8″
				33° 22′ 09.6″	43°37′ 14″
8	Babylon to Basra -2020		12	32° 40´ 1.147´´	44°19´21.214″
				30 48 8.42″	47°35´19.32″
	Total Sample	78	73		

2. Analyses of water and sediments samples

The researchers used many techniques and methods for the analysis of water and sediment samples in their studies. The ions of water samples are obtained through many techniques, including the Flame photometric technique via flame photometers for Na^+ and K^+ ions. EDTA titrimetric method (Ethylene Diamine Tetracitic Acid) for Ca^{2+}, Mg^{2+}. Argentometric way (silver nitrate process) for Cl-. Turbidimetric method and colorimetric method for SO_4^{2-}. HCO_3^-: Titration method by using indicator titrated per HCl for CO_3^{2-}. Ultraviolet spectrophotometric screening method by spectrophotometer with wavelength 220 nm for NO_3 (Kenkel, 2003). pH–meter; the EC: Conductivity TDS meter, cyber scan10, TD Gravimetric manner (Boyd, 2000). Atomic absorption spectrometer/ plus or Atomic Emission Spectrometry (ICP-AES) for trace elements (e.g. Cu, Ni, Co, and Cd).

Sediments were collected from the banks or the bottom of the river. The sediments have been dried by the sun and air, or in a circulating oven at 30 °C. Afterward, using an agate mortar, a 2 mm sieve was mechanically and homogenized to produce clay fractions for different analyses (Agyarko, et al., 2014) and were grounded softly.

A thin section was prepared for mineralogy. XRD techniques are used to identify clay plus non-clay components of minerals in the river sediments. XRF technique is used for chemical analysis using one gram of sample for the formative analysis of the major oxides and trace elements (Holland and Turekian, 2014).

Results and Discussion

The most important and recent results of chemical analysis of the water and sediments of the Euphrates River in Iraq from the Al-Qaim to the Basra Governorate are based on these previous studies and scientific references discussed as follows:

1. Hydrochemistry and water quality

The physical water properties are TDS, pH, and EC, in addition, TSS is within suitable Iraqi Standards (2001) and WHO Standard (2006). Color, taste, and odor are likewise found in accepted limits; then in Hit City, limited pollution is produced using spring water, which increases the detrimental taste and water smell. This pollution will be diluted by the Euphrates River, which makes it suitable for taste and smell after a short distance (Awadh and Ahmed, 2013). The Euphrates River waters have the highest composition mean values for rare earth elements in the evaluation of the other basic river waters.

Human activities have negatively affected the water quality and hydrogeological characteristics of the Euphrates River. Its sediments are contaminated with Cr, Pb, Ni, Zn, and Cd from several urban sources (Issa, 1995). Anthropogenic sources are important factors in the development of Cd in the Euphrates sediments. These consist of water discharged for irrigation; enriching the phosphate fertilizers on the way to the Euphrates River alongside its Iraqi path, and discharging organic urban sewage water to the river course as a result of being devoid of management in extremely populated cities (Al-Bassam, 2011).

The Euphrates River water is divided into two interesting subdivisions, hard water in the greater parts when it is entering Iraq from the Syrian boundary; in addition, actual hard in the mid-lesser parts. Major and minor ions of the river are within the standards excepting TDS and TH in amount to physical and chemical parameters, and Ca^{2+}, Na^{+}, Cl^{-}, SO_4^{2-}, CO_3^{2-}, and H_2S in proportion to major and minor ions, are more than the used limits.

Trace elements are within the standards except for As, Fe, Pb, Sb, and Sr. The water of the Euphrates in the lower part is unfit for drinking. The water is good to very good for livestock and irrigation (Qanbar, 2016). All surface water samples are suitable for building purposes, except the maximum concentrations (610.0 and 499.5 ppm of HCO_3^{-}) in Batha station at low and high periods, respectively, which are incompatible for building purposes due to increasing bicarbonate ions. The surface water of the river is not suitable for industrial uses, but stations of Hindiya Barrage1, Hindiya, and Hindiya Barrage2 are suitable for leather tanning, and stations of Shamiya and Dewaniya 2 are suitable for soft drink bottling (Qanbar, 2016).

The rise in pollution is a result of the waste discharge commencing from many sources like native wastewater; industrial units in addition to farming water, the water quality was assessed to be good (Mohammed et al., 2021).

In the city of Samawa, the level of concentration of mineral elements at the Spatio-temporal level of Euphrates is relatively high. This is due to several factors, both natural and man-made. The release of countless industrial and farmed pollutants and additional city pollutants led to a decline in the water class of the River in the city and also the spread of pollutants through the networked water liquefaction areas in the study area. This water poses a major threat to the health of the city's residents (Al-Rubaie et al., 2021).

Previous data (chemical analyses) are collected for the physical and chemical parameters of the Euphrates River water in Iraq over the past ten years for comparison and interpretation of the chemical temporal changes of the river water (Table 2. and Fig. 4).

The water chemistry is characterized by having $Na\text{-}SO_4$ and Na-Cl in 2013 as the dominant ions, while the water chemistry changed during the year 2021 to be characterized by Na-Cl. The change in the chemistry of Euphrates water is due to climatic fluctuations towards drought, human consumption, industrial use, discharge of domestic wastewater, and urban activity (Table 2).

Previous data (chemical analyses) are collected for the physical and chemical parameters of the Euphrates River water in Iraq over the past ten years for comparison and interpretation of the chemical temporal changes of the river water (Table 2 and Fig. 3).

Table 1. Results of the previous studies water chemistry of Euphrates River

Physiochemical Parameters		Awadh and Ahmed, 2012	Al-Paruany, 2013	Qanbar, 2016	Mohammed et al., 2021	Al-Rubie et al., 2021
T.C°		27.5	20.4	25.97	−	-
TSS		16	49	1390.6	-	-
PH		7.7	7.55	*8.15*	7.2	-
EC (µs/cm)		1137	857	1902.6	1717.6	2738
TDS	ppm	564	597.2	1390.6	862.3	1889.4
Ca^{2+}	ppm	63	102	135.7	−	143.9
Mg^{2+}	ppm	23	15.32	63.4	−	130
Na	ppm	101	74.7	220.8	−	123.5
K^{+}	ppm	1.44	2.6	5.34	−	10.4
$SO_4^{=}$	ppm	219	189	442.9	−	486
Cl^{-}	ppm	134	119.7	321.2	−	710.3
HCO_3^{-}	ppm	70	149.5	182.2	−	264

The physical and chemical variables of the Euphrates River water for the previous ten years (2012–2022) are illustrated in Fig. (3) and Table (2). It can be noticed that the physical and chemical variables are constantly changing as their values have increased in recent years. The decrease in river drainage, lack of water supply, climatic changes, increased human consumption, industrial use, and discharge of domestic wastewater led all to these changes. In most studies, the predominant ions are SO_4^{-2}, as an anion, and the cation Ca^{2+} in Euphrates water.

Sulfates may originate from multiple sources: oxidation of sulfide ores; dissolution of evaporite rocks, for example, gypsum and anhydrite; in addition to anthropogenic resources represented by agricultural additives such as fertilizers and pesticides, where Iraqi fertilizers contain a proportion of sulfate (TSP 1.5; NP 0.58, MAP 0.64, NPK 2.35) (Al-Qaraghuli, 2005).

From the data evidence shown above, it is clear that the Euphrates River is contaminated with heavy elements whose concentration exceeds both Iraqi and global health standards. However, depending on the urban activity in each Governorate that the river flows through, pollution may be localized (Al-Rubaie et al., 2021). This is demonstrated by the high levels of trace elements in the river water between Hit and Al-Saqlawiya cities, which are situated along the river almost 150 km long. The Euphrates River in Najaf Governorate is contaminated by household wastewater pollution, heavy sewage, agricultural residues, chemical fertilizers, and pesticide particles.

In Nasiriya City, there is pollution from some metals such as Cr, Pb, Ni, Zn, and Cd. In the Samawa area, natural and added human-by-city discharges are the ones that rise the water pollutants to levels that exceed health standards approved by the WHO and are acceptable globally. In the southern parts of Nasiriya and Basra cities, several measured physicochemical parameters for water, such as EC, TDS, pH, and T confirmed the rise in salinity and other ions of the river compared to various world standards (Hussain and Al-Jabari, 2020).

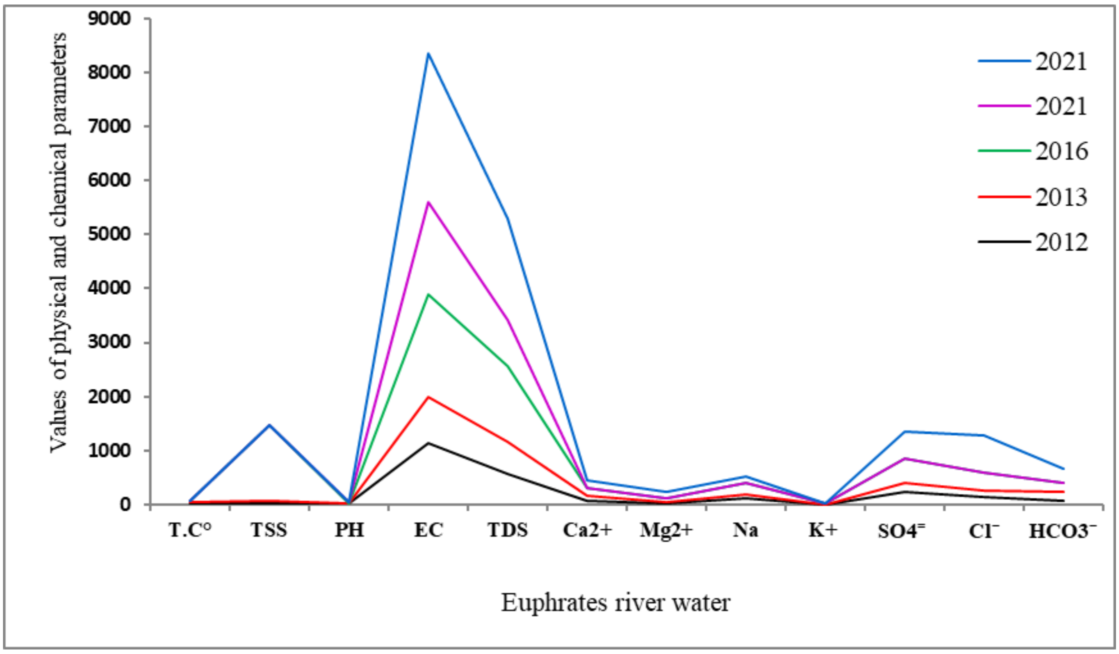

Fig. 3. Chemical temporal change for Euphrates river water

This is a clear indication and proof of the worst changes in physiochemical components of the water of the Euphrates River as it flows toward the cities of Nasiriyah and Basra in southern Iraq. The increase in urban consumption and use for various purposes and climatic conditions led to an increase in the concentrations of total dissolved solids. It negatively affected the water quality, which became poor and unsuitable for human consumption and drinking.

2. Sediment Geochemistry of the Euphrates

The chemistry of the Euphrates river sediments is derived from the geology and minerals of the region and has a direct impact on the distribution of the main oxides and trace elements, in general, and from a tectonic view. Its arrangements contact those in the Iraq Platform (Inner and Outer), until the adjacent Haditha. At that point, it streams inside Al-Jazira Zone, then parallels with the Abu Jir–Euphrates fault, and finally with the Mesopotamian Plate (Sissakian et al., 2018). The basin of the river is enriched with dissimilar non-metallic minerals to a huge extent. Limestone, and dolostone, in addition to glass, are extensive in massive sizes. Additionally, the basin comprises many oil and gas fields (Sissakian et al., 2018).

Trace elements are analyzed at +63µ for the sediment fraction of the Euphrates River distribution pattern in the different sectors of the river. The analyses show that metastable heavy minerals make up about 50% of the total content, while ultra-stable heavy minerals make up only about 5%. Opaques are present in high proportions, amounting to approximately 32% on average, and decreasing towards the south. Pyroxene is the highest (32%), followed by hornblende (18%). This study shows the presence of many trace elements in the sediments of the Euphrates River, whose source is the igneous rocks, in addition to sedimentary complexes in Turkey and Syria (Al-Bassam and Al-Mukhtar, 2008).

Materials weathering of the parent rock is the record of different oxides forms in the sediments of the river (Yong et al., 2012). The mean abundance of the major oxides of the Euphrates River bed sediments follows the order of SiO_2> CaO> Al_2O_3> Fe_2O_3> MgO> K_2O> Na_2O> TiO_2> SO_3> P_2O_5. The mean concentration of trace elements in the riverbed sediment samples follows the order of Mn> Cr> Sr> Ba> Ni> V> Zr> Zn> Rb> Cu> Pb> Ga> Y> Co> Mo> Nb> As> Br> Th (Hussain and Al-Jaberi, 2020).

Concerning the chemistry of sediments along the Euphrates River, consistent with sediment features guidelines, Euphrates sediments are polluted with Cd, Cu, Ni, Fe, Mn, and Cr. EF standards propose that Euphrates sediments are very highly contaminated with Pb, Cd, Co, and Ni to moderate with Zn, Mn, and Cu (Salah et al., 2012).

Some trace elements are also determined in the surficial sediments of the Shatt Al-Hilla River. This study concludes that pollution levels, according to I_{geo} for Pb, Fe, and Cu metals in all sites are unpolluted except Ni in all sites, which falls into non-to-moderate pollution levels due to the accumulation of this metal from various anthropogenic sources (Al-Rubaie et al., 2021).

Non-clay minerals (dolomite, gypsum, quartz, calcite, and feldspar); in addition to clay minerals (palygorskite, kaolinite, illite, chlorite, and smectite) are determined in the studied zone of the Euphrates River. The mean content of major oxides in the studied area is ordered CaO> Fe_2O_3> MgO> Al_2O_3> SO_3> K_2O> TiO_2> P_2O_5> Na_2O. By using the elemental ratio calculated to Al, which is used to recognize and assess the main element mobility, the Euphrates River sediments are enriched in Ca and Mg, and to some extent, enriched in Si, while the sediments are medium-enriched in Fe and Ti major elements, and depleted in Na and K major elements. The mean values of trace element concentration in the area are, in order Mn> Sr> Ni> Cr> V> Zn> Cu> Co> B> Pb> As> Sc> Fe> Se> Cd (Al-Jaberi and Hussein, 2020).

Generally; B, Co, Cu, Mn, Ni, and Pb elements do not have serious environmental consequences because of their low mobility, while Se, V, Zn, and also B cause dangerous environmental consequences because they have a high degree of mobility under neutral or alkaline conditions. The elements Sr, Sc, Fe, Cr, and Cd range from medium to very low mobility under neutral or alkaline conditions (Holland and Turekian, 2014). The content of trace elements such as B, Co, Cu, Mn, Ni, and Pb in the sediments of the Euphrates River has a low degree of mobility. This occurs under neutral or alkaline conditions and depending on the hydrogen sulfide concentrations and the pH of the river sediments in the area. The correlation analysis of mean concentrations displayed respectable positive strong relationships in the middle of Pb, Cd, Fe, Mn, Zn, Ni, Co, and Cr signifying that these metals have communal sources. Co, Cd, and Cr are responsible for very high contamination. Anthropogenic impacts on the sediments of the Euphrates River in the study area are assessed using enrichment factor, contamination factor, pollution load index, and geo-accumulation index for the metals As, Cd, Co, Cu, Cr, Mn, Ni, Pb, Sc Se, Sr, V, and Zn (Issa and Qanbar, 2016).

Carbonate minerals, quartz, and anorthite feldspar are the light minerals in the different depth intervals of the river sediments in the study area, with a share of the clay fraction consisting of kaolinite, palygorskite, and chlorite. Carbonate minerals, which are calcite and dolomite, are the main non-clay minerals. Carbonates are higher than quartz. The highest amount of calcite is recorded in Basra/ Qurna City, while in Diwaniya and Hilla cities it is the lowest. Most CaO is attributed to limestone formation, and carbonate mollusks of various species dominate the river's macrofauna. The domination of calcite with a lack of dolomite is reflected in the MgO content. Redox element (ferric) content in the sediment study cores is high within the uppermost part of the profile. Several mechanical and chemical features are detected; conchoidal, rounded, pits, and granular micro (Al-Jaberi and Hussein, 2020).

River sediment analysis is considered a useful procedure for revealing environmental pollution with trace elements (Batley, 1989). The values of pollution indicators EF, CF, and I-Geo, show that Ni and Mo are the most important trace elements seriously polluting the riverbed sediments in some sites of the study areas. The health risks study of riverbed sediments reveals that the trace elements Co and Ni at Hilla and Diwaniya cities reached a concentration that poses serious health risks to children and adults alike. The metals Co, Cr, and Mn indicate obvious health risks for the population in the Samawa, Nasiriya, and Basra cities, especially with the continuous addition of these elements through anthropogenic activities (Hussain and Al-Jaberi, 2020).

Table 3 documents the most toxic trace element concentrations in Euphrates River sediments in selected areas. Studies have been documented by detailed chemical analyses of trace elements for nearly a quarter century for selective and comprehensive geological studies. A comparative study and interpretation of the most important chemical changes of common trace elements in the Euphrates sediments are carried out. This is done by drawing a chart showing items with higher concentrations over the years (Fig. 4).

Table 2. Recognized hazard heavy metals concentration in land use sediments

Previous studies		Cu	Zn	Co	Ni	Pb	Cr	Cd
Researcher	Year							
Issa	1995	-	102	-	186.4	51.8	176	10.1
Al-Bassam	1998	24.1	53.9	46.5	163.9	27.1	104	3.2
Al-Lami,	2002	23.2	27.7	-	115.4	24.3	-	0.9
Al-Bassam	2008	45.3	91.2	48.6	182.9	19.5	-	3.6
Ahmed	2011	52.5	-	14.7	57.1	13.5	47.4	-
Al-Bassam	2014	15	55	-	83	5.0	180	-
Qanmber	2016	27.2	60.5	20.3	175.9	8.8	82.4	0.2
Hussain	2020	31	82	18	176	23	466	-

The curves in Fig. (4) indicate that the concentrations increase with the progression of the years. This indicates that the Euphrates River sediments are increasingly polluted with toxic trace elements such as Ni, Cr, and Zn, according to previous studies during the last 25 years (1995 to 2020). Likewise, Co, Cu, and Pb are in the second rank in pollution and danger. The concentrations of trace elements that researchers have studied for a quarter century are of a comparatively heterogeneous distribution due to differences in time and site. This confirms that the source of pollutants is the geological setting, mineral composition of sediments as well as the urban activities in Iraqi cities.

Cadmium precipitation might happen in elevation activities of Cd^{2+} under alkaline and anaerobic environments at pH> 7.0. Cadmium in the solution of soils is ruled by sulfide precipitates. The Cd is very mobile in the oxidizing environments at pH< 3 and in low-content Fe-rich particles, but it is less mobile in the existence of oxidizing particulates at pH> 5. Yet, in the reduction as well as the presence of hydrogen sulfide (pH> 5), there is a high movement of Cd (Kabata-Pendias and Sadurski 2008).

Phosphate fertilizer applications increase the concentration of Cd in solution soils. However, the rise in Cd concentration too, owing to its desorption in the soil medium that happens in the low pH of the soil (Alloway, 1995; Taylor and Percival, 2001).

Carbonates can incorporate trace elements, here they move with the solution into the sediment in a reducing environment (Abboud, 1999). Regarding the Euphrates River in Iraq, the distribution and high concentrations of trace elements Ni, Cr, and Zn in the sediments are the case.

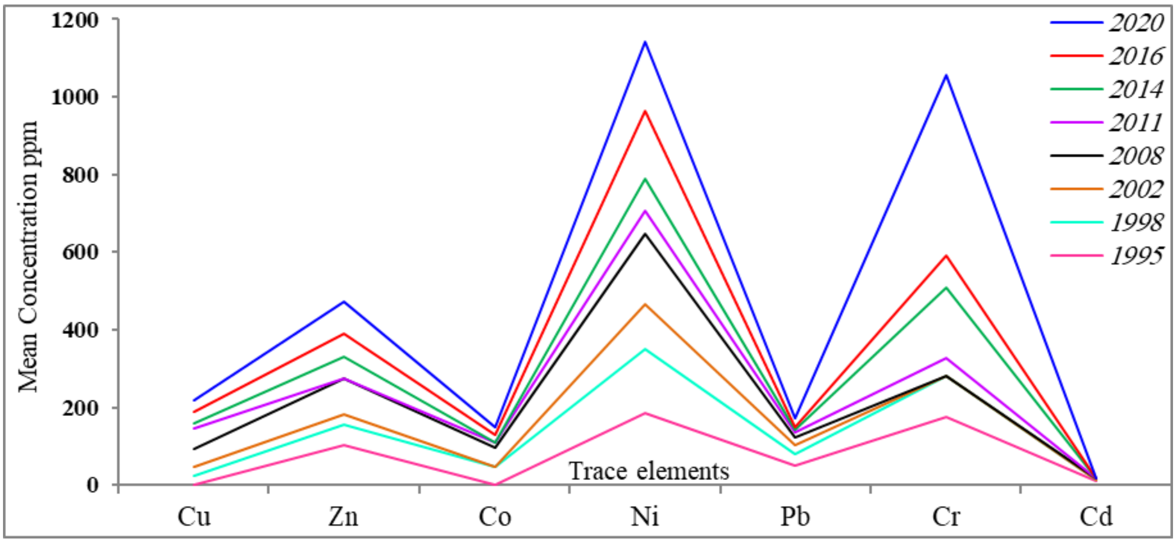

Fig. 4. Chemical temporal change of trace elements for Euphrates river sediments

This is attributed to a rise in agricultural and industrial land use as a result of agricultural exploitation and industrial waste on the banks of the river. "Mean Cu content" may refer to anthropogenic activities. According to Senesi et al. (1999), the high cobalt values are related to fuel combustion and phosphate fertilizer as a result of agricultural activities. The high Zn values are affected by agricultural activities, where, in particular, superphosphate can significantly contribute to Zn-enhanced levels in sediments (Kabata-Pendias and Mukherjee, 2007). This is concluded through the above results and interpretations of previous studies given in Tables (2 and 3). A review of the current article is conducted for the official survey to identify and understand the geochemistry of the trace elements of the sediments and waters of the Euphrates River with time, as well as to explain the high level of salinity in the waters of the river towards Basra Governorate to the south, in addition to the high concentrations of some important toxic elements in the river beds.

Conclusions

The Euphrates River is an important focus of the researchers of geology, hydrology, environment, and people attention as well as an important source of water supplies for human consumption for various purposes in several Iraqi Governorates located within the western and southern deserts. Therefore, it is necessary to work on reviewing previous research and studies, from which the following could be concluded:

The article on the chemistry of Euphrates water discovered a perfect and clear result between 2012 and 2021. The change in the chemistry of Euphrates water is due to climatic fluctuations towards drought. The high temperature and the lack of precipitation caused large amounts of salts to be deposited in the river bed.

North of the study area; from a geological setting of the river basin, big quantities of evaporates are deposited on the river bed. This condition depleted salts in the river water. At that point, sequential rainfall of the salts, led to an elevation in the total dissolved solids content (TDS) of river water by the sequential dissolution of the salts. The additional ions are augmented, rendering their solubility.

Through the study of many previous scientific studies on this subject, it is clear that the water of the Euphrates River has suffered changes in its specifications and an increase in pollution and salinity towards the south along the course of the river from the city of Al-Qaim to the city of Basra, represented by an increase in the relative concentrations of total dissolved solids and the concentrations of cations and small anions.

Lack of drainage of water in the river and severe climatic changes are represented by drought, lack of rainfall, and high temperatures, as well as the drying up of lakes and groundwater wells feeding the river. Urban activities, as another source, cause an increase in pollution with trace elements and TDS as a result of the discharge of water to the river represented by untreated sewage, the water of agricultural activities that are contaminated with fertilizers, pesticides, organic materials, and industrial waste from electric power stations.

In sediments of the river; from drawing the concentration curves for a quarter century for trace elements, it is clear that there is a rise in the concentrations of toxic trace elements such as Cu, Ni, Co, and Cd. There is an agreement about the increase in elements Cr, Ni, and Cu from 1995 to 2020. The intensification of their content in the sediments of the Euphrates River towards Basra City with the growth in water salinity is because of the climatic changes that have occurred in recent years and the tendency towards desertification of the region. The geological setting, mineral composition of sediments as well as the urban activities in Iraqi cities had a most important and characteristic role in accumulating the concentrations of toxic trace elements and polluting the sediments of the Euphrates River.

Recommendations

Treatment of wastewater that yields industrial activities such as thermal power plants, flood streams, and sewage pipes before being discharged directly into the Euphrates River and recycling and customizing this water for irrigation and domestic uses. Rationalizing water consumption. Reducing urban, industrial, and agricultural activities that lead to pollution of the river. Overtaking of the rivers' banks must be prevented. Iraq should negotiate with upstream countries to increase water releases for Iraq to obtain its water quotas and treat water scarcity.

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