Abstract:

The study area is located in the northern Iraqi province of Erbil, covering a total area of about 1400 km^2 (3.5% of Iraq). The Erbil basin is mostly covered by Quaternary deposits, with only a few outcrops of Miocene-Pliocene formations in the east and northeast of Sharabot-Dedawan highlands, Avanah Mountain in the west and southwest in narrow strips, and Damirdagh in the north. Deposit lithology ranges from clay, silt, sand, and gravels (sandstone, clay stone, and conglomerate). Erbil Basin, also known as Dashty Hawler basin, Erbil provinces is largest groundwater reservoir, with a surface area of 3200 km^2 and a depth of approximately 800 meters (2). Erbil Basin, one of the Middle East's most important groundwater basins, is bounded on the north by the Greater Zab River and on the south by the Lesser Zab River. Thirty water samples (27 samples of ground water wells), and (3 samples of waste water channels) were collected during May (Water surplus period) and September (Water deficit period) 2020 in Erbil central sub-basin and analysed. Physical analyses includes temperature (T), pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD5), Chemical oxygen demand (COD), Dissolved oxygen (DO), Total Suspension sediments (TSS), whereas the geochemical analysis included concentration determination of the major, minor and trace elements. The aim of this article is to evaluate the pollution in groundwater of Erbil central sub-basin due to different kinds of waste water, the samples of water in the study area were collected from deferent locations and sources, deep wells, waste. all chemical, physical and trace elements parameters are presented in this work, the pollution has been founded in the study area due to waste water by Kahrez (old ground water distribution in Erbil basin), cesspools and septic tanks.

Keywords: Groundwater contamination, water quality, hydrochemistry, waste water Erbil Central Sub basin

Dedication

I dedicate this project the head of the department and to the research supervisor and finally to all those who would benefit from this project. Presented to all who brought the Kurdistan closer to freedom and happiness with their minds, words and lives.

Acknowledgment

We acknowledgement our utmost appreciation to Dr. Masoud, the supervisor, the college librarians, the internet center at college of science which exposed us to a variety of project details on the web as well as to all those who made this project feasible. Also many thanks go to Hawler general health directorate ,department of Environmental protect.

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Chapter: One

1. Introduction

Ground water resources have been under rapidly increasing stress in large parts of the world due to pollution by human activity. Pollution is primarily the result of irrigated agriculture, industrialization, and urbanization, which generates diverse wastes, with the attendant impact on the ecosystem and growth ground water. With a rapid increase in population and growth of industrialization, groundwater quality and quantity is being increasingly threated by the disposal of urban and industrial solid waste). Groundwater is major source of water supply for domestic, recreational, and industrial purposes in Erbil city and around it. Consequently, the adequacy of ground water resources, both in quality and quantity, is essential for socioeconomic sustainability in the area. Ground water resources are very important for public water supply. Many of the environmental problems are directly or indirectly related to location of ground water and its protection from contamination sources of various kinds. The environment at which waste is disposed poses a major problem on ground water. Solid wastes are produced every day in urban societies as a result of human activities and in an attempt to dispose of these materials; man has carelessly polluted the environment (Badmus, et al., 2014).

1.1. Aim **of study**

The aim of the study is to determine pollution of ground water and the source of pollutants in Erbil city which is located in the central -sub basin, as well as to evaluate their suitability for drinking consumption according to Iraqi standard for drinking and World Health Organization (WHO). The main sources of ground water pollution in this sub-basin are:

1-Municipal (waste water).
2-Domestic (Cesspools, Septic tank).
3- Agricultural activities
4-Industrial wastes
5-Natural pollution (Lithology).

The waste water comes from, domestic (house waste water), industrial waste water, street waste water. But the cesspools and septic tank wastes is filters into the groundwater directly.

Problem of the study; there is an academic gap in researches of Erbil central sub-basin, no new researches of water quality in last few years. Erbil city the is highly populated governorate in the region, they are for water quality is important for the population more than quantity. Urbanization causes fluctuation in quantity and quality of groundwater.

1.2. Description of the study area

Study area situated in Erbil governorate, in northern part of Iraq and the total area of the region is about 1400km^2 (3.5%of Iraq). The study area lies between latitude 36o08'30"-36o14'15"N on the east by longitude 43° 51'20"-44°12'28"E (Figure 1.1) and with an elevation ranges between 600 to 415 m above sea level.

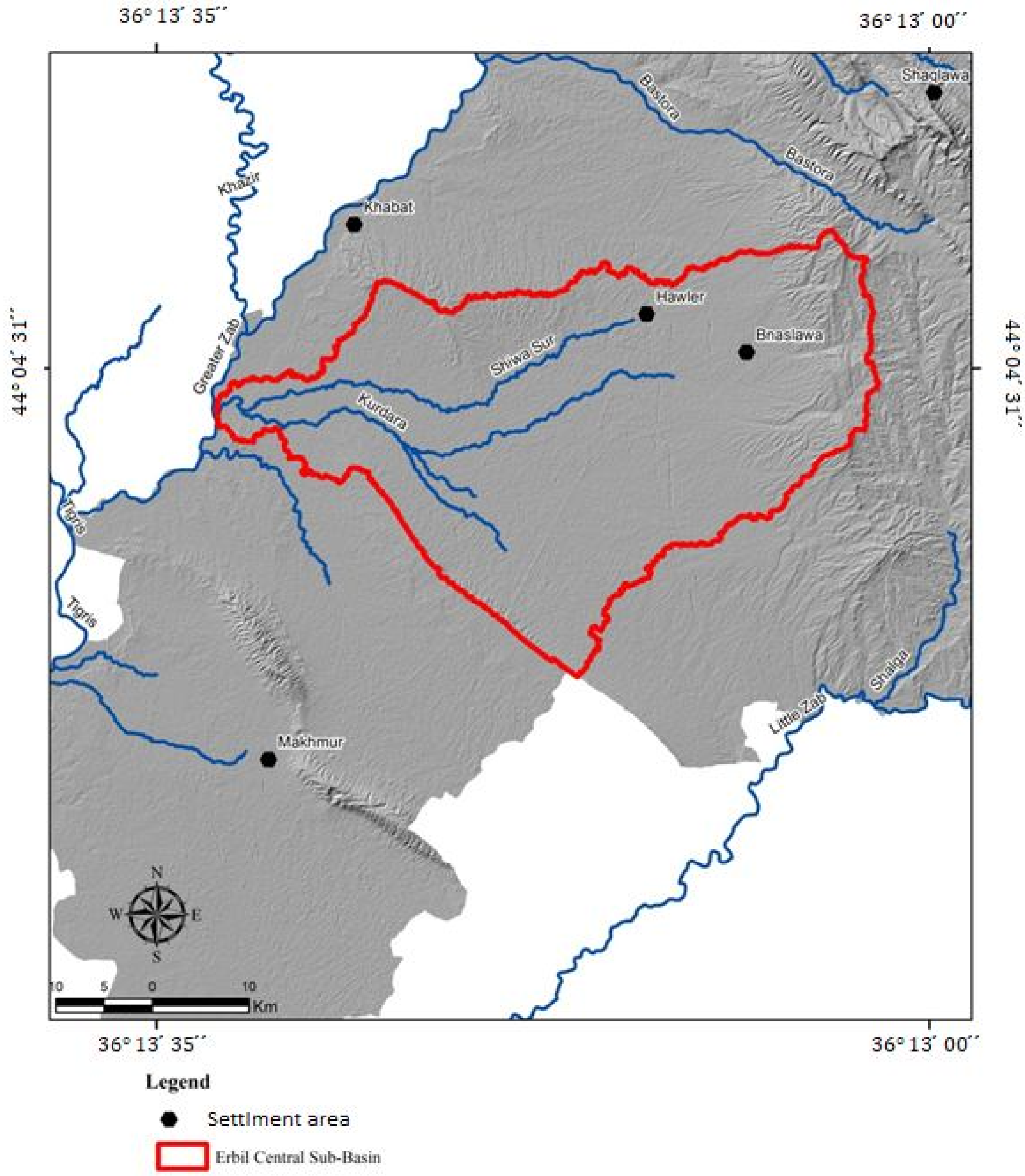

Figure 1.1. Erbil Central Sub-Basin Map.

1.3. Ggeneral geology of the sstudy area

Erbil basin is mostly covered by the Quaternary deposits with relatively small areas of outcrops of Miocene – Pliocene formations in the East and Northeast of Sharabot – Dedawan high lands, the Avanah Mountain in west and southwest in a narrow strip, and Damirdagh in the north. The lithology of deposits is various from clay, silt, sand, and gravels (sandstone, claystone, conglomerate). Recent deposited in the basin covers the rock units in Shamamik basin, these deposits are non-effected by Alpine orogeny, consist of clay, loam silt, sand, and gravel. Stratigraphy of quaternary deposit is unconformable with underling unit (vertically and horizontally appeared gravel alterative (repeat) coarse, medium, and fine grain size) (1). The age of quaternary deposits is Pleistocene to Holocene. These deposits were divided according to our field expert:

River terraces were produced by recent flood plain exposed along each side of valley, produced by variation in base level or by climate variation in area along valley. The age is Pleistocene; consist of rock fragment limestone, fragment, gravel (silica) and little amount of igneous and metamorphic rock fragments. Flood Plain Deposit sediments originate as a result of river erosion during flood periods. They consist of clay, silt, sand, and gravel with some fine pebbles, and rock fragment(figur1.2). The age of this deposit is Holocene. Geomorphologically the area located in Erbil plain the highest point in Sharabot area it reaches about 600m above sea level and lowest point located in the west of the area reach 415 m above sea level, Drainage types area dendritic.

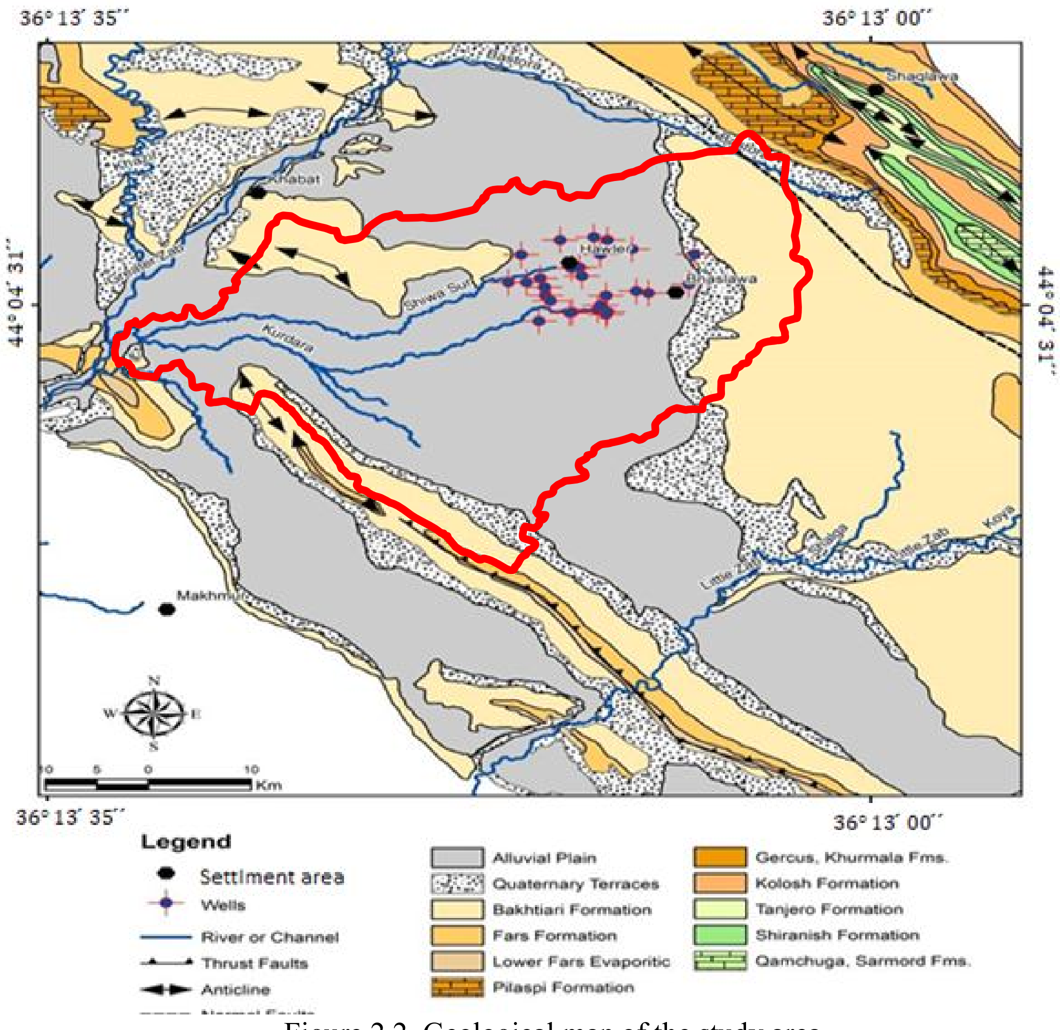

Figure 2.2. Geological map of the study area

1.4. Hydrogeology of Erbil basin and central sub-basin

The Erbil Basin, also known as the Dashty Hawler basin, is the largest groundwater reservoir in Erbil province, with a surface area of 3200 km^2 and a depth of roughly 800 meters (2). The Erbil Basin, one of the most significant groundwater basins in the Middle East, is bounded on the north by the Greater Zab River and on the south by the Lesser Zab River. The Erbil Basin is a huge depression region that lies between the Pirmam anticline's southern limb and the Dibaga hill zone, giving it a semi-circular form (3). The Bakhtiary Formation, in particular, is a prominent aquifer in the Erbil Basin, consisting mostly of soils, gravels, and conglomerates with occasional sands, clay, and silt (Quaternary deposits) and thickly-bedded conglomerates, sandstones, and shale (Quaternary deposits) (the Bakhtiary Formation). While Quaternary deposits (alluvium and terraces) are mainly unconfined aquifers across the study region, the Bakhtiary Formation is typically semi-confined to the confined aquifer (2). The water table in Erbil city and its environs, according to Erbil water directorate (2020), is between 50 and 160 meters deep.

1.5. Erbil wastewater channels

The Erbil sewer system is built for storm water and in most cases, domestic sewers are illegally connected with storm sewer, both (combined rainwater and sanitary sewer) from the Erbil wastewater channel. The extension of this wastewater channel is from the southwest of the Erbil city with an extension of about 50 km that passes through vast farmlands, orchards, and several villages, wastewater effluent discharges into the Greater Zab after Gameshtape village. The Erbil Wastewater Channel consists of three different wastewater channels: the Bnaslawa Wastewater Channel, the Zhyan Wastewater Channel, and the Turaq Wastewater Channel (Figure 1.1) and the Zhyan wastewater channel effected directly on the groundwater of water well and caused pollution in the area (Figure2.1)_.

Chapter: Two

2. Materials and Methods

Surface water (Zhyan, Bnaslawa, and Turaq Wastewater Channels) and groundwater (well) samples in the vicinity of the study area were analysed by the water quality control unit in Erbil Water Quality Control Department (EWCD) and Erbil Environment Directorate Water Quality Control Unit (Iraq). The hydro geochemistry study was undertaken by randomly collected from 30 samples in the vicinity of the study area during 20 May 2020 and September 2020 including 27 groundwater (deep wells) samples, and 3 surface water samples from channels. Locations of the samples (coordinates in UTM system) were recorded with a GARMIN GPS 78s using WGS84 reference and are shown in Table 2.1. All water sample 0.

locations were shown in Figure 2.1. During the sampling, in-situ measurements of physicochemical parameters such as temperature and DO were immediately measured in the field by multipara meters. Also, values of pH and EC were measured immediately in the field using calibrated EC-pH meter with standard solutions, while the levels of TDS were measured in the laboratory (Table 2.2). Chemical analysis for the major cat ions and anions of all water samples were analysed in EWCD and Erbil Environment Directorate Water Quality Control Unit (Erbil, Iraq). Before sampling, all sampling containers are thoroughly washed and rinsed with groundwater or surface water, depending on the sampling location. Then the water samples were collected from the wells and wastewater channels using polyethylene bottles with a volume of 1.5 litter for physicochemical parameter tests, trace elements test, and glass bottles that had been cleaned with acid for the biological test, during the transportation all samples were refrigerated (about at 4°C).

Table 2.1. Elevation and groundwater level data (in meters) of the study area.

Sampling Location	Well code	Surface Elevation (m)	Total Depth of well (m)	Static groundwater level depth (SWL)		Groundwater Level (water table)	
				May.20	Sept.2020	May.20	Sept.2020
Kasnazan ,15	Ka-15	612	250	165	180	447	432
Bnaslawa ,43, cemetery	Bn-43	537	320	115	123	422	414
Hawlery new,7	Ha-7	485	300	110	120	375	365
Kwestan , 1	Kw-1	473	300	93	102	380	371
Bnaslawa ,19	Bn-19	466	320	105	125	361	341
Badawa,37	Ba-37	464	350	104	118	360	346
Iskan,1	Is-1	463	180	89	97	374	366
North Industry , 6	No-6	456	250	94	105	362	351
Gullan,8,cemetery	Gu-8	446	300	86	98	360	348
Daratu , 4	Da-4	443	330	92	108	351	335
Sharawani , 4	Sh-4	434	250	75	80	359	354
Daratu , 23,cemetery	Da-23	433	300	95	108	338	325
Zhyan, 11	Zh-11	424	330	93	110	331	314
Roshanbeery,12	Ro-12	415	300	96	115	319	300
Kurani Ainkawa,2	Ku-2	415	250	90	95	325	320
Roshanbeery,7	Ro-7	415	300	98	105	317	310
Erbil great cemetery	Er-Gr	411	300	87	105	324	306

Sampling Location	Well code	Surface Elevation (m)	Total Depth of well (m)	Static groundwater level depth (SWL)		Groundwater Level (water table)	
				May.20	Sept.2020	May.20	Sept.2020
Zhyan , 13	Zh-13	406	330	95	108	311	298
Ashty ,2	As-2	403	200	60	68	343	335
Gilkand ,3	Gl-3	401	200	48	57	353	344
Nawroz ,16	Na-16	395	200	55	62	340	333
South Industy (Shadi ,13)	So-13	393	250	91	103	302	290
Sarbasty ,10	Sa-10	391	250	56	68	335	323
Kurdistan , 11	Ku-11	390	160	73	79	317	311
Mardeen,3	Ma-3	389	250	80	88	309	301
Gerd Muhamad ,2	Gr-2	385	240	73	82	312	303
Turaq ,4	Tu-4	380	200	50	55	330	325

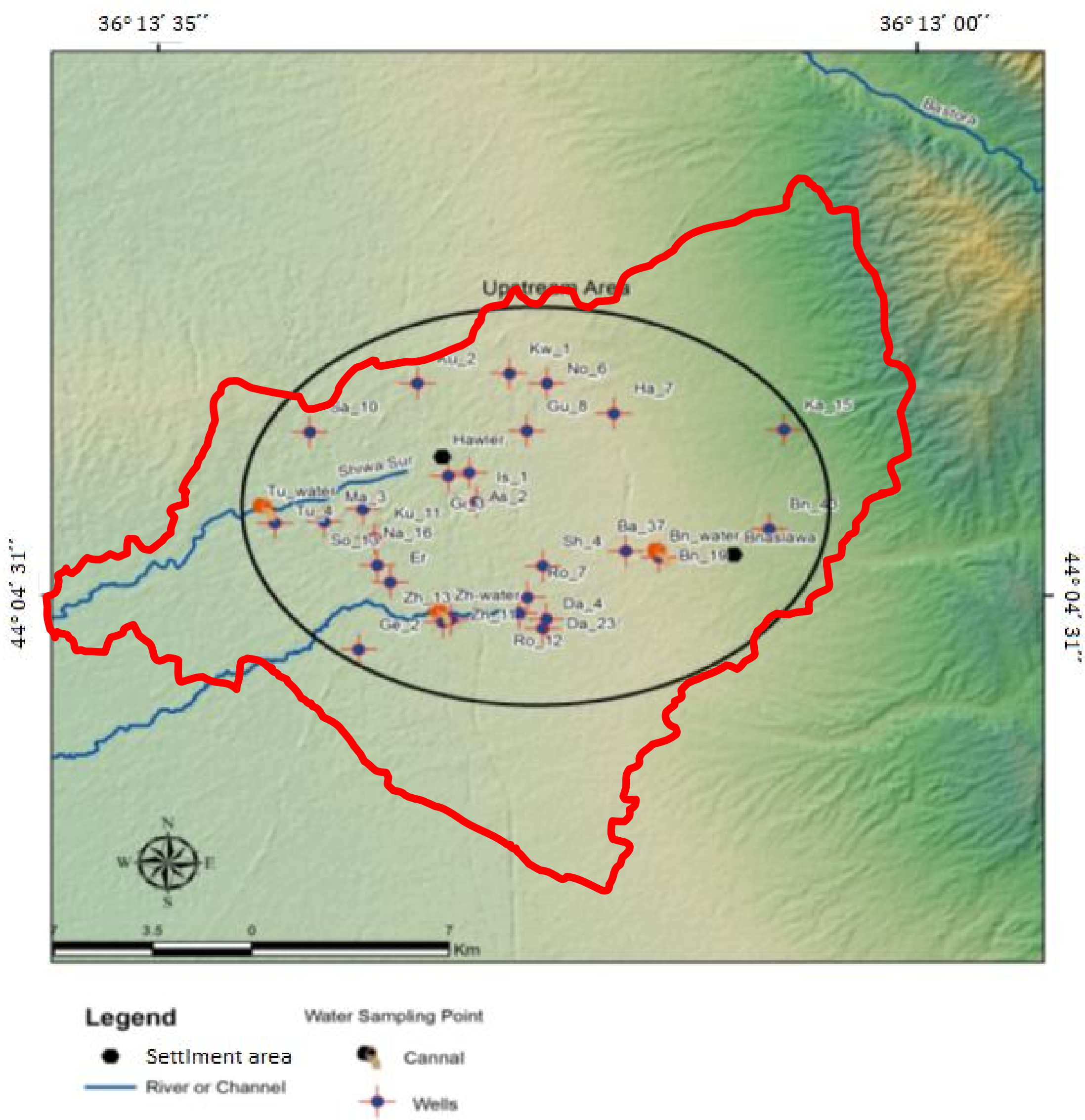

Figure 2.1. Sampling location map of the study area.

Table 2.2: Analytical techniques used in measuring the various parameters.

Parameter	Analytical method
Temperature C°	Field thermometer
pH- value	Field pH- meter
Total hardness (T.H)	Titration with EDTA (0.01N)
Calcium & magnesium	Titration with EDTA (0.01N)
Sodium& Potassium(Na & K)	Flame photometer
Nitrate ,Nitrite, and phosphor	spectrophotometer
Sulphate(SO_4)	Titration with EDTA (0.02N)
Hydrogen-sulphide(H_2S)	Titration with sodium thio -sulfate
Chloride(Cl)	Titration with $AgNO_3$(0.01N)
Bicarbonate(HCO_3)	Titration with HCl (0.01N)
Turbidity	Turbidity meter
Trace element	Atomic absorption spectrophotometer
Chemical oxygen demand (COD)	Titration with sodium thio- sulfate
Dissolved oxygen and biological oxygen demand (Do & BOD_5)	Titration with sodium thio- sulfate
Total dissolved solids (TDS)	TDS meter portable
Acidity	Titration with (0.01 NaOH)

In addition, statistical analyses were done using the SPSS statistical program (version 23.0 for Windows). The Pearson correlation matrix was used to analyse the similar/different source for physicochemical qualities in the sampled water well samples using the measure of the probable linear connection between two continuous variables (4, 5). Principal component analysis (PCA) or factor analysis (FA) is a widely used statistical method for determining which factors, such as natural and anthropogenic processes affecting surface water and groundwater quality, are primarily involved/impacted in the creation of chemical variation in groundwater (5,6; 7). Cording to the basic geochemical parameters of the constituent ionic concentrations (8).

Chapter: Three