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Project proposal

Suggested Title for the Ph.D.:

Determination of Recharge area using Environmental Isotopes in Karstified Aquifers in Balisan area, Kurdistan Region, Iraq

Key words: Environmental isotopes, Karstic aquifers, Cretaceous formations.

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1. Overview

Karstic and fissured aquifer systems are famous sources of water in the study area (Balisan). Groundwater is increasingly under pressure due to contamination and climate change. Water scarcity in the last few years in the area give arise to investment in the groundwater rather than surface (because of rainfall deficiency. Following classic ways didn't lead to enough knowledge about the origin and recharge of groundwater. Using isotopes (environmental isotopes) will give a prices and descriptive model of origin, and recharge location of karstic aquifers.

2. Description of the Area

The area is located in the northeast of Iraq (NW of Sulaimani city) west of Dokan Lake (Figure 1). The hydrologic basin of the area is belongs to Dokan sub-basin which locates in the sub-basin in Lesser Zab River Basin (Jwad, 2008). The hydrologic aquifer of the area represents a karstified groundwater system situated within Cretaceous rock units (Qamchuqa and Kometan formations). Composition of the aquifer is mainly limestone and dolomitic limestone (Figure 2). Three major springs Zewa, Chewai Saru and Bla springs (or more according to the occupation of the studied area) are proposed to be studied. All the mentioned springs are famous and major springs in the area and used for irrigation and other domestic uses. The karst outlets (springs) seems to be like the below model (Figure 3), but the recharge area was unknown.

3. Objectives

The proposed project aims to solve many environmental problems in the karstified groundwater system of Balisan area. The main objectives of the project are: Using environmental isotopes (e.g. ^{18}O and ^{2}H) to investigate

- a- Recharge area of groundwater source.
- b- The origin of groundwater.
- c- Mathematical models of karstified system using environmental isotopes.
- d- Flow regime of groundwater.

Hydrogen, carbon and oxygen are the dominant constituents in karst waters, karst bedrock, speleothems, travertine deposits, and in dissolved bicarbonate which is normally the dominant anion in karst water. Fortunately, these elements all include stable isotopes that exhibit variations large enough to be routinely measured with mass spectrometers (Goldscheider and Drew, 2007). Environmental isotopes are chosen because they are natural and wide distribution in the hydrosphere can assist in the solution of hydrogeochemical problems (Kendall and McDonnell, 1998). According to Kendall and McDonnell (1998) typical uses of environmental isotopes in hydrology include:

- ✓ identification of mechanisms responsible for stream flow generation
- ✓ testing flowpath and water-budget models developed using hydrometric data
- ✓ characterization of flowpaths that water follows from the time precipitation hits the ground until discharge at the stream
- ✓ determination of weathering reactions that mobilize solutes along those flowpaths
- ✓ determination of the role of atmospheric deposition in controlling water chemistry
- ✓ identification of the sources of solutes in contaminated systems and assessment of biologic cycling of nutrients within an ecosystem

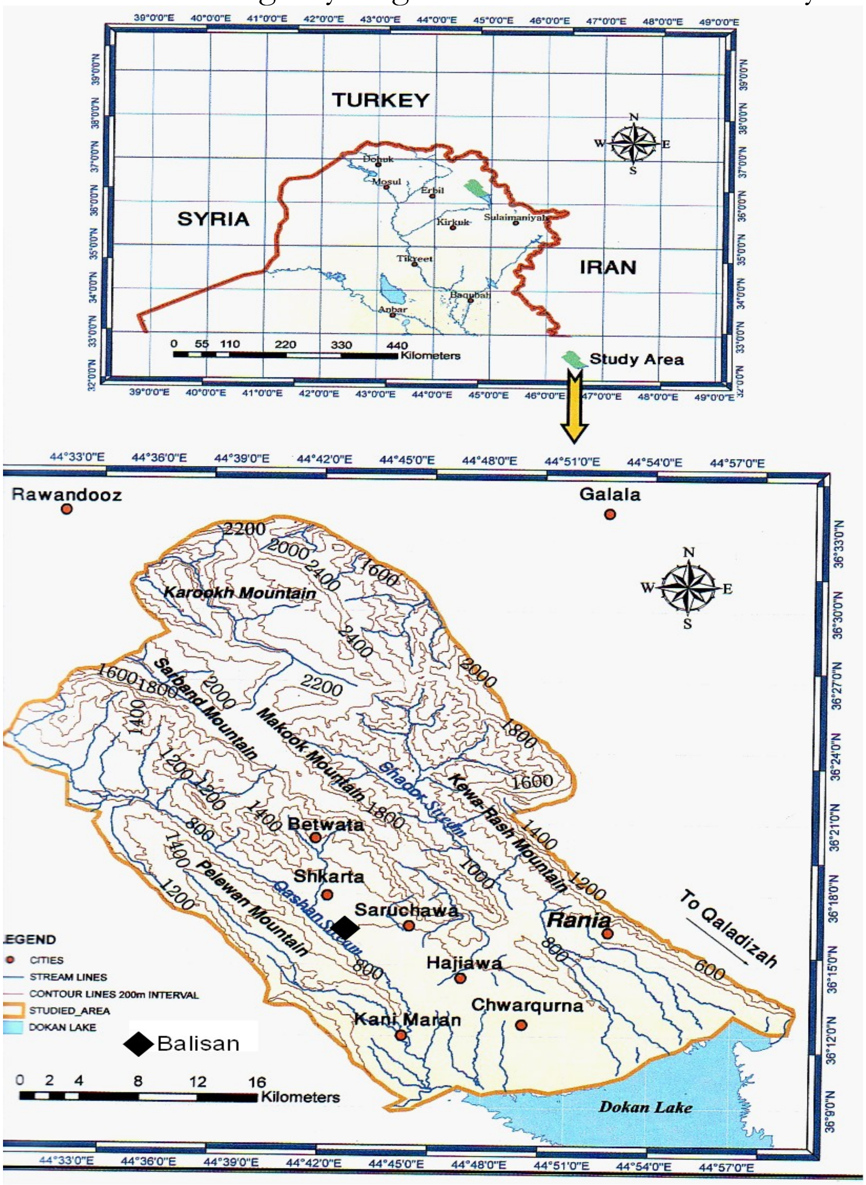

Figure-1: Location of the studied area (After AL-Manmi, 2008)

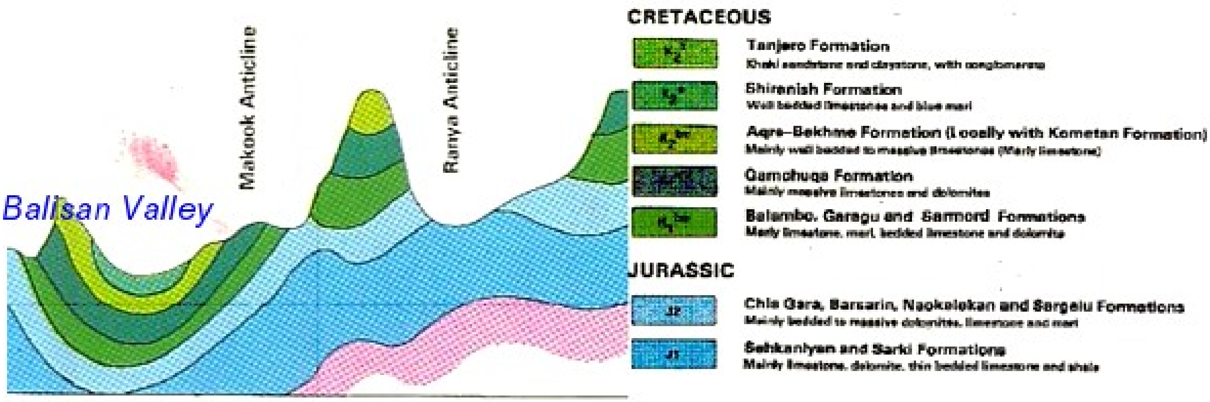

Figure 2: Geological cross-section of the area (Modified from: GEOSURV, 1997)

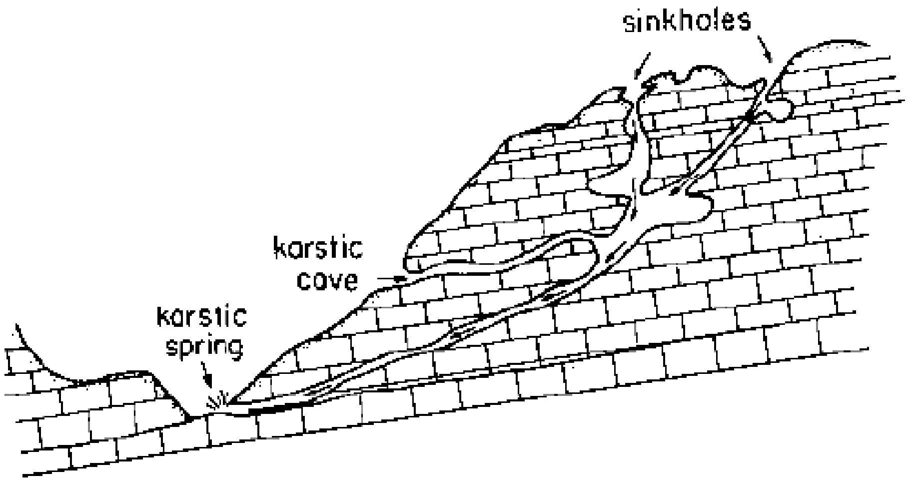

Figure 3: Components of Karstic system (Mazor, 2004)

Finally, management of the water resources in the area using the above data and other model approaches is one of the aims.

The aim of the research is to solve Environmental problems of water using isotopic tools. General headlines in this work related to my previous M.Sc. research work which includes water quality and management of water resources. Groundwater including deep and shallow aquifers and surface waters including lake waters represent the main source of potable (drinking) water that could be protected and managed through the mentioned tool. These types of works and studies are very little and new in my country so it might be a good contribution for pushing and courage the protection of water resources. Migration, storage properties and water dynamics will be determined using environmental isotopes as tracers. Taking courses about environmental isotopes, water resources management, and contaminant behavior in water and water-rock interaction contribute to add knowledge to my previous studies and make my vision wider toward my interest field of study.

4. Literature and Research Review

-Al-Manmi, 2008 study the water resources management in Rania area which locate east-north east of the Balisan area. The study includes chemical and isotopic study of the different groundwater systems.

-Schlag, 1999 study Denitrification in the Elk Valley Aquifer using nitrogen isotope.

- Pence, 1996 study Hydrogeology and Recharge of the Split Rock Creek Aquifer, South Eastern South Dakota using stable isotopes (^{18}O and ^{2}H).

5. Methodology

Using environmental isotopes (^{18}O and ^{2}H) are the best useful method for investigating of groundwater origin (according to some reviewed works done in other areas but not especially on Karstic zones).

The location of a sampling point can be recorded accurately by using the global positioning system (GPS). Also, note the date and time of sampling.

Collection of geologic, hydrologic and hydrogeologic data in the field will be the initial step of the field works.

5.1 Apparatus & Equipments

Many field and lab equipments and apparatus were required during the study. The below list represent majority of them:

1- All wheel drive automobile
2- GPS, Compass, feet, etc
3- Portable multi-parameter
4- Sampling containers and cooled box
5- Rain sample collector (gagging station)
6- Lab system containing isotope mass spectrometer (IRMS)

5.2 Sampling

Proper sampling and field measurements of both physicochemical parameters and isotopic measurements are critical to ensure high quality analysis and reliable interpretation of data (IAEA, 2010).

Sampling for oxygen-18 and deuterium is simple. No sample filtration (unless they contain oil or contain abundant particulate matter) or preservation is required. Fill a 50 mL, double capped (figure 4), glass or polyethylene bottle directly from the source or from a secondary container. The water sample is put in a clean dry bottle, which is filled almost completely to the top (Kendall and McDonnell, 1998). Clearly label the sample with all details. Make sure the bottles are tightly capped. During sampling, storage and transportation to the laboratory take care to avoid evaporation of the sample (IAEA, 2010). Freezing does not affect the composition of the water but can break the bottles in transit; for this reason, many users prefer plastic bottles. Our experience suggests that caps with conical plastic inserts (e.g., "poly-seal" caps) are the most reliable, followed by teflon-lined caps. For extended storage, use of glass bottles and waxing of the caps is advisable. Sample-size is lab-dependent; typical volumes range from 10-60 mL. In some laboratories, samples as small as a few µL can be analyzed (Kendall and McDonnell, 1998).

Determinations of both hydrogen and oxygen isotope ratios are usually made on the same bottle of water. It is wise to collect many more samples than one can afford to analyze at the present; samples have a long shelf life if bottled correctly, and can be archived for future analysis. One should make sure that the laboratory chosen to analyze the samples normalizes their values according to IAEA guidelines (Kendall and McDonnell, 1998).

Continuous sampling monthly for main springs and precipitation are proposed to achieving the required data for hunting recharge source.

5.3 Field Measurements & Works

In situ field measurements (conductivity, temperature, pH, dissolved oxygen and alkalinity) will be taken besides the isotope sampling. Sampling for isotopes will take place monthly (one time) from springs and rainwater for the proposed locations.

5.4 Laboratory Works

Isotope mass spectrometer (IRMS) will be used for analyzing the stable isotopes (^{18}O and ^{2}H) in the lab.

5.5 Subject Area of Courses

The core courses cover the theoretical and applied aspects of Environmental Hydrogeology. The courses are tend to develop the knowledge, values, and skills necessary to enable me to enhance the knowledge base of the field and utilize interdisciplinary research methods to pursue the understandings of environmental hydrogeology, and to contribute to the understanding of effective practice of integrated environmental research. The main courses are includes Isotope hydrology, Hydrogeochemistry, Karst hydrology, Tracer Hydrology, Contaminant Transport, Groundwater Modeling and Water resources management.

6. **Proposed Timetable**

The time scheduling of the P.hD can be distributed as below:

1- First year, theoretical background courses through two semesters, including the following courses (optional and depend on the supervisors vision):

No.	Course	Duration	Semester
1	Isotope hydrology	3 months (20 hours)	1st
2	Hydrogeochemistry	3 months (20 hours)	1st
3	Karst hydrology	3 months (20 hours)	1st
4	Tracer Hydrology	3 months (20 hours)	1st
5	Contaminant Transport	3 months (20 hours)	2nd
6	Groundwater Modeling	3 months (20 hours)	2nd
7	Water resources management	3 months (20 hours)	2nd

2- Second year, practical works including pre-field work (training on isotope sampling), field works (in situ measurements and sampling) and lab works (analyzing and statistical works).
Sampling will be conducted as bellow:

Site	Time of Collection	No. of Samples	Total No. of Samples
Zewa spring	Monthly	3 replicates	36
Chewai Saru spring	Monthly	3 replicates	36
Bla spring	Monthly	3 replicates	36
Rainwater (3 or more stations)	Monthly	3 replicates	Vary

3- Third year, represent the final and includes the assessment and discussion of the results and building better way of water resources management in the area.

7. **References**

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