EVALUATING WATER QUALITY OF WARAZ MOUNTANEOUS AREA, USING CONTAMINATION INDEX, SULAIMANIYA GOVERNORATE, NORTHEAST IRAQ

Omed M. Mustafa*

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ABSTRACT

This study aims to investigate the degree of contamination of Cadmium and Copper on both surface and groundwater in Waraz area, using Contamination index (C_d). For this purpose, surface and groundwater samples were collected from various locations of Grdazubair Stream and groundwater of Waraz Village. Grdazubair Stream, in the studied area is highly contaminated with Cadmium (Cd) and showed contamination index ($C_d > 3$). Contamination index (C_d) increases moving from up to down-stream along Grdazubair Stream. Groundwater also shows high degree of contamination. A source of the contamination in water of the area is geogenic and derived from sulfide mineralization in the exposed igneous rocks of the area. Water of the studied area is not useful for drinking purposes, because of high degree of contamination with health risky elements like Cadmium. Contamination index represents a useful tool for evaluating quality of surface and groundwater in the mountainous area.

تقييم نوعية المياه لمنطقة واراز الجبلية باستخدام دليل التلوث، محافظة السليمانية، شمال شرق العراق

أوميد محمد مصطفى

المستخلص

إن الهدف من إجراء هذه الدراسة هو بيان و تقييم درجة التلوث الآتية من العناصر الثقيلة (كادميوم و نحاس) على المياه السطحية و الجوفية في منطقة واراز الجبلية. في سبيل تحقيق ذلك استعملت طريقة معامل التلوث (C_d) التي تأخذ بعين الاعتبار عدد الملوثات و الحد الأعلى المسموح به لتواجدها في المياه. جمعت عدة نماذج من مواقع مختلفة من نهر كردة زوبير والمياه الجوفية في قرية واراز. تعتبر المياه الجوفية في قرية واراز ومياه نهر كردة زوبير مياه ملوثة بعنصر الكادميوم (Cd) اعتمادا على معامل التلوث (ملوث جدا). تزداد درجة التلوث كما يزداد تركيز عنصر الكادميوم عبورا من أعلى نهر كردة زوبير نزولا الى أدنى النهر. يرجع التلوث العالي في مياه نهر كردة زوبير والمياه الجوفية في قرية واراز الى المصادر الجيوجينية المنحدرة من الصخور النارية، كالصخور البازلتية ومحتوياتها من المعادن الكبريتيدية. تعتبر مياه المنطقة مياه غير صالحة للشرب بسبب درجة التلوث ويعزى ذلك الى العناصر المضرة بالصحة مثل الكادميوم، ويفضل تصفية ومعالجة المياه قبل استعمالها لغرض الشرب. تعد طريقة معامل التلوث (C_d) طريقة ناجحة لتقييم نوعية المياه السطحية والجوفية في المناطق الجبلية.

* Assistant Lecturer, University of Sulaimaniyah, College of Science, Dept. of Geology
e-mail: omedgeology@yahoo.com

INTRODUCTION

Quality of water takes interest of the researchers and consumers (for drinking and irrigation), through which populations are exposed to harmful elements from industrial, anthropogenic and/ or geological origin. Many techniques are used for assessment and visualization of hazardous defined elements. One of the approaches to calculate contamination of water bodies is through Contamination Index (**C_d**), which takes into consideration both the number of parameters exceeding the upper permissible limits or guide values of the potentially harmful elements (Backman *et al.*, 1998). Calculation of the contamination degree (**C_d**) was carried out separately for each analyzed sample of water, as a sum of the contamination factors of individual components exceeding the upper permissible values. Hence, the contamination index summarizes the combined effects of several quality parameters considered harmful to household water. According to (Backman *et al.*, 1998), the calculation scheme of (**C_d**) is as follows:

$$C_d = \sum_{i=1}^{n} C_{fi}$$

where:

$$C_{fi} = \frac{C_{Ai}}{C_{Ni}} - 1$$

C_{fi} = Contamination factor for the i th component

C_{Ai} = Analytical value of the i th component

C_{Ni} = Upper permissible concentration of the i th component

The studied area is located 30 Km northeast of Sulaimani City (Fig.1), it represents a part of Mawat Ophiolite Complex (Valanginian – Maastrichtian) (Buday, 1980) and metamorphosed in Late Cretaceous (Jassim and Goff, 2006), which represents a thrusted nappe (Bolton, 1957 and Aswad, 1999).

Lithologically, the area is composed of Gabbro (Fig.2), Diabase (Aswad, 1999), Diorite, Quartz-Dolorite (Jassim, 1972), Basalt, Andesitic Basalt, Boninite, Peridotite (Firjo, 2006). The mineral composition of these rocks is clinopyroxene, orthopyroxene, amphibole, plagioclase, chlorite, quartz, sulfide minerals, calcite and epidote (Firjo, 2006).

In this study, water samples were analyzed for two main trace elements (Cadmium and Copper), which represent environmental contaminants. Upper permissible concentrations of Cadmium and Copper applied for calculation of contamination index (C_d) are 0.003 and 2 ppm, respectively, according to WHO (2006).

The studied areas is characterized by cold and snowy winter with high precipitation rate, low air temperature and long, warm and dry summer. Autumn and Spring are very short. Typical semi-arid climatic condition is prevalent in the studied area (Stevanovic and Markovic, 2003).

The studied area extends from Waraz Village to Grdazubair Stream, showing sub-parallel to dendritic drainage pattern (Fig.1). Grdazubair Stream represents permanent stream extending from northeast (Grdazubair Village) to south of Waraz Village. Discharge of the stream ranges between (500 – 980) l/ sec from up to down stream (Table 1). Groundwater in the area belongs to different aquifers. Two major springs with discharge of water (1.5 – 8) l/ sec occur in Waraz Village (Fractured Ultrabasic aquifer) and a third one near Waraz bridge (Fractured Metabasalt aquifer).

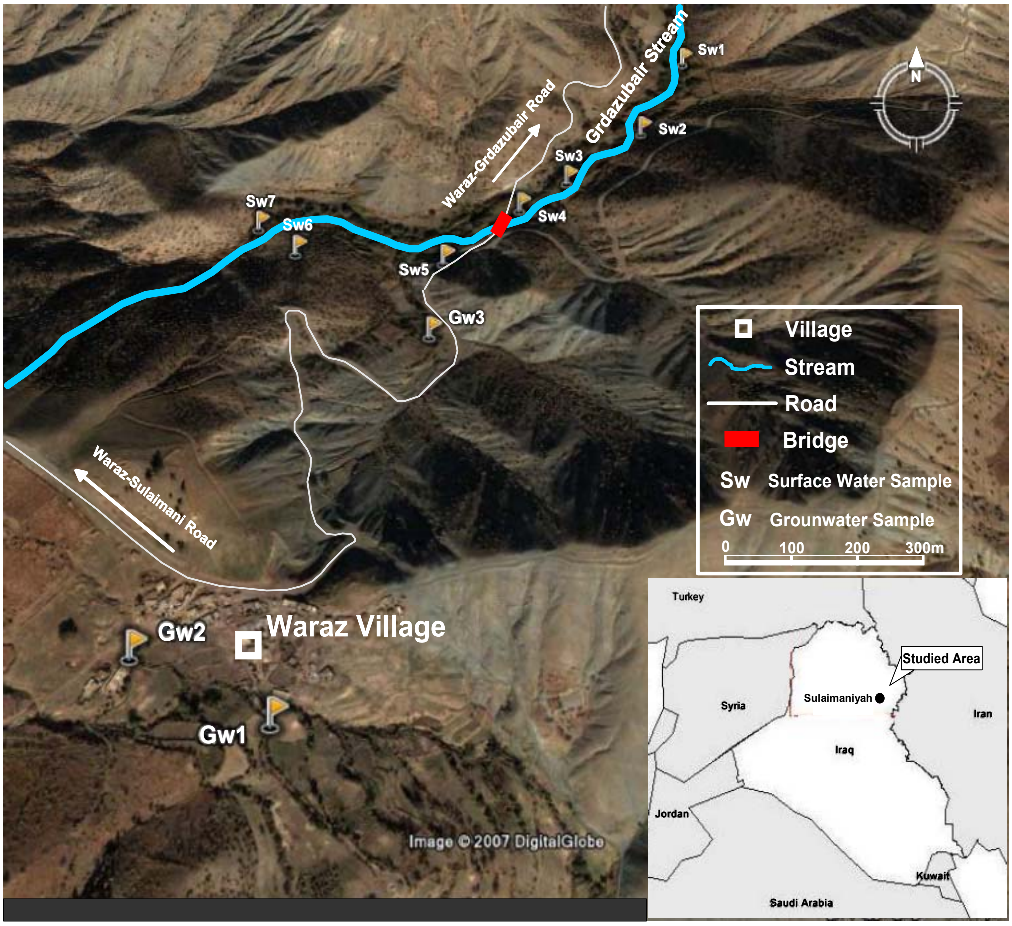

Fig.1: Location Map of the studied area

METHODOLOGY

Ten water samples were collected from different locations in Waraz area (Fig.1), including surface and groundwater samples (Table 1). Attitude of sample locations were acquired using GPS and plotted on Google satellite image (Google, 2007) to create location map of the studied area (Fig.1). Groundwater samples collected from Waraz Village's springs, which mainly are used for household purposes (drinking) and irrigation. Surface water samples collected from Grdazubair Stream, in which every station is selected in equal distances along the stream from up to down stream. Each sample container is rinsed with dilute HCl and distilled water in the laboratory and washed 3 times by sampled water, then filled and stored 7 days till analyzed in the laboratory. The samples were analyzed 3 times for accuracy in Geochemical Laboratory of Geological Department (University of Sulaimaniyah) for Cadmium (Cd) and Copper (Cu) using AAS (Atomic Absorption Spectrophotometer) model BUCK-210 VGP, according to APHA (1998).

Also, five physiochemical parameters were measured for each sample (pH, Electrical Conductivity-Ec, Temperature, Turbidity and TDS) using Portable Multiparameters Field Lab Analyzer, model TPS 190 FL-T (Table 3).

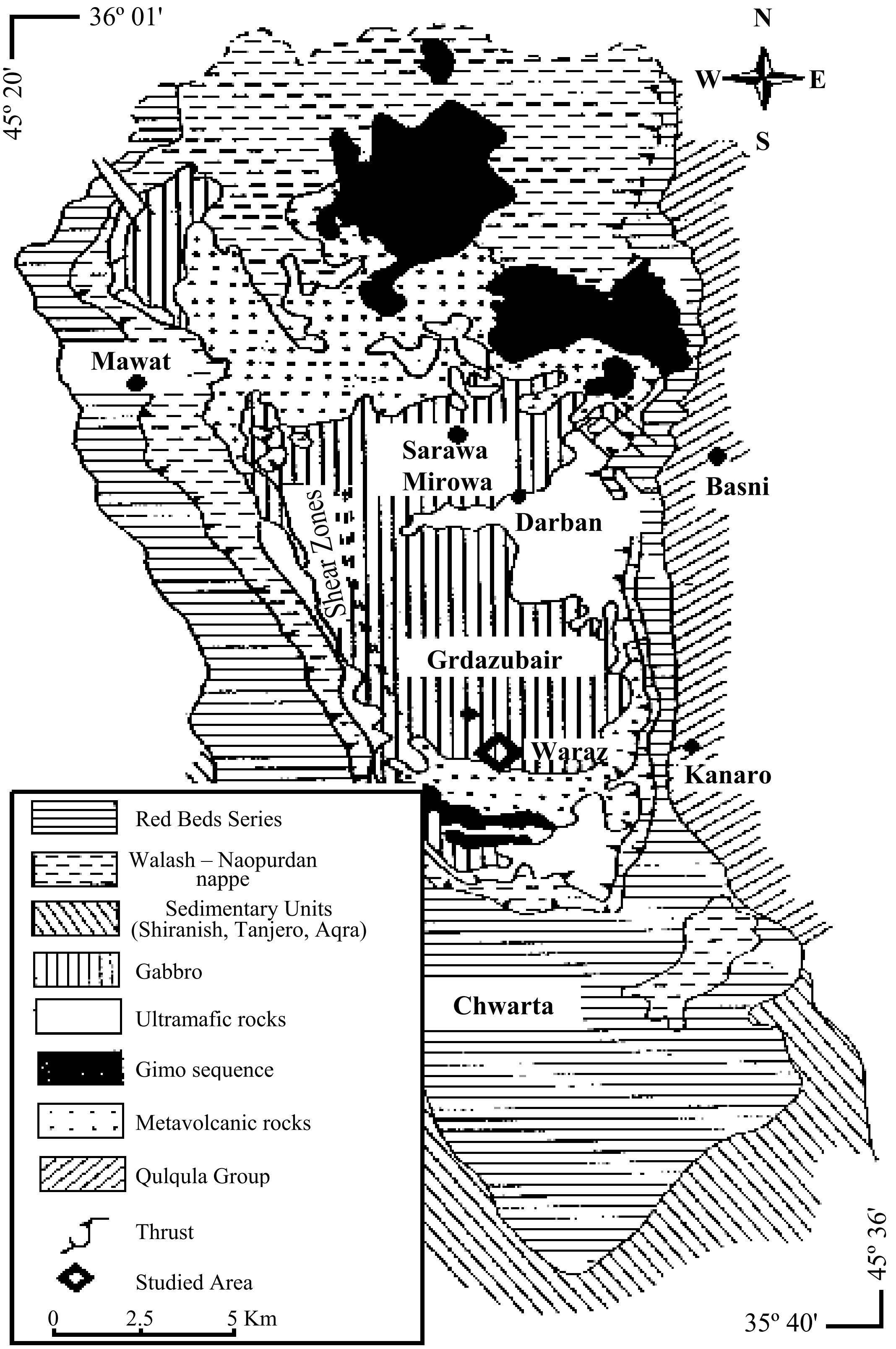

Fig.2: Geologic map of the studied area (after Al-Mehaidi, 1975)

Table 1: Location and sampling station description

Sample No.	Attitude	Description
Sw1	35º 47.69' N 45º 31.074' E H = 1150 m	Surface water sample from upstream, W = 4 m, D =(30 – 40) cm, Discharge = 500 liter/ sec
Sw2	35º 47.581' N 45º 31.010' E H = 1140 m	Surface water sample, W = 5 m, D = (45 – 50) cm, Discharge = 700 liter/ sec
Sw3	35º 47.531' N 45º 30.922' E H = 1137 m	Surface water sample, W = 4.5 m, D = (20 – 30) cm, Discharge = 750 liter/ sec.
Sw4	35º 47.496' N 45º 30.868' E H = 1131 m	Surface water sample, Bridge station, W = 3.5 m, D = 45 cm, Discharge = 900 liter/ sec
Sw5	35º 47.432' N 45º 30.786' E H = 1132 m	Surface water sample, W = 5 m, D = 45 cm, Discharge = 850 liter/ sec
Sw6	35º 47.444' N 45º 31.697' E H = 1120 m	Surface water sample, W = 3 m, D = 50 cm, Discharge = 920 liter/ sec
Sw7	35º 47.492' N 45º 30.573' E H = 1117 m	Surface water sample from downstream, W = 3.5 m, D = 60 cm, Discharge = 980 liter/ sec
Gw1	35º 47.04' N 45º 30.689' E H = 1256 m	Groundwater from main spring of Waraz, fractured ultrabasic aquifer, Discharge = 6 – 8 liter/ sec
Gw2	35º 47.075' N 45º 30.584' E H = 1274 m	Groundwater, uptown stream of Waraz, fractured ultrabasic aquifer, Discharge = 3.5 – 6 liter/ sec
Gw3	35º 47.348' N 45º 30.777' E H = 1143 m	Groundwater from spring away from Waraz bridge by 500 m, fractured metabasalt aquifer, Discharge = (1.5 – 3.0) liter/ sec
H = Height, W = Stream width, D = Stream depth		

Table 2: Analytical value (C_{Ai}), Contamination factor (C_{fi}) and Contamination Index (C_d) of samples

Sample No.	C_{Ai} (Cd) ppm	C_{fi} (Cd)	C_{Ai} (Cu) ppm	C_{fi} (Cu)	C_d
Gw1	0.2683	88.43	0.0841	– 0.95	87.47
Gw2	0.2808	92.6	0.0953	– 0.95	91.64
Gw3	0.2586	85.2	0.0785	– 0.96	84.24
Sw1	0.2912	96.06	0.0747	– 0.96	95.0
Sw2	0.2545	83.83	0.1495	– 0.92	82.9
Sw3	0.2975	98.16	0.1084	– 0.94	97.2
Sw4	0.3370	111.33	0.0990	– 0.95	110.37
Sw5	0.3515	116.16	0.1401	– 0.92	115.23
Sw6	0.4417	146.23	0.1364	– 0.93	145.3
Sw7	0.4209	139.3	0.1514	– 0.92	138.37
Gw = Groundwater sample, Sw = Surface water sample					

Table 3: Physiochemical Parameters of Water Samples

Sample No.	pH	Temp. (ºC)	Turbidity (NTU)	Ec (µS)	TDS (ppm)
Gw1	6.95	16.1	9.0	688	409
Gw2	7.54	16.0	15.0	582	345
Gw3	6.83	16.0	10.0	290	116
Sw1	7.95	16.2	7.0	312	126
Sw2	7.84	16.3	8.0	311	125
Sw3	7.87	16.2	30.0	312	127
Sw4	7.81	16.1	16.0	309	124
Sw5	7.86	16.2	17.0	312	126
Sw6	7.73	16.2	25.0	312	125
Sw7	7.96	16.3	19.0	289	116
Gw = Groundwater sample, Sw = Surface water sample, Ec at 25º C					

Table 4: Classification of Contamination Index (Backman *et al*., 1998)

C_d	Class
$_d < 1$	Low Contamination
1 – 3	Medium Contamination
$_d > 3$	High Contamination
C_d = Contamination Index	

RESULTS

Calculated values of contamination index for water samples are shown in Table (2). Degree of water contamination is classified into three grades (Backman *et al*., 1998) (Table 4).

Water samples with:

$C_d < 1$ represents low contamination level
$C_d = 1 – 3$ medium represent contamination level
$C_d > 3$ represents high contamination level

All surface water samples show high contamination level ($C_d > 3$) ranging between 82.9 – 145.3 (Table 2). Groundwater samples also show high contamination index value, ranging between 84.24 – 91.64 (Table 2).

DISCUSSION

From the results of surface and groundwater samples, it's clear that both are highly contaminated with Cadmium (Cd), also concentration of Cadmium (Cd) exceeds those of natural streams (Drever, 1988). Source of this contamination is geogenic, because industrial and other anthropogenic sources of contamination are absent and agricultural activity avoids using of pesticide, which represents possible source of Copper (Hem, 1985). Crustal materials (igneous rocks) like basalt with sulfide-mineral composition (pyrite, chalcopyrite and sphalerite), oxides like (magnetite) and weathering product like greenokite-CdS (Holland and Lollar, 2003 and Rose *et al*., 1979) represent the source of cadmium contamination of water (Yukselen, 2002 and Fazeli *et al*., 1998).

Health effects associated with excess Cd are generally kidney and liver damages, cardiomyopathy, metabolic acidosis, lung disease and itai-itai disease (Florea, *et al*., 2005 and Holland and Lollar, 2003).

Lower analytical value of Copper in water samples (Table 2), which does not exceed the upper permissible level of 2 ppm, according to WHO (2006), results from Copper deposits in Waraz area are found as a small malachite disseminated lenses in metabasalt (Jassim and Goff, 2006). The acidity and temperature of water in the studied area (Table 4) cause low concentration of Copper (Davis and Dewiest, 1966). Contamination index increases down stream along Grdazubair Stream in the studied area, showing cumulative effect of elemental concentration.

Application of contamination index indicates that water of the studied area (both surface and groundwater) are health-risked and not suitable for drinking purposes, so clarification and remediation are recommended.

CONCLUSIONS

- Surface and groundwater of Waraz area show high contamination index value, indicating high degree of contamination in Grdazubair Stream and Waraz groundwater.
- Contamination degree increases down stream of Grdazubair Stream, so as Cadmium concentration.
- Geogenic source, including basaltic and other igneous rocks with sulfide-mineralization represent the main source of water contamination.
- Highly contaminated water of Waraz area is not suitable for drinking purpose, and clarification is recommended.
- Application of contamination index for evaluating quality of surface and groundwater is useful in mountainous area.

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