Investigation of pollution level of groundwater in the ALjazaier Area, Babil

N S Hadi 1*, Z S Jabbur 1

1 Department of Environmental Engineering, College of Engineering, Babylon University, Iraq
* Corresponding author: nabaa.hadi@uobabylon.edu.iq

Abstract

A total with 15 samples was collected from 3 wells in the aljazaier distreet in Babil governorate for the period from January to April 2020, to study the microbial contamination represented by fecal bacteria, while chemical contamination includes a physicochemical and the heavy element's properties. The goal of this study: Study the water of some wells from some microbes and chemical aspects and evaluate this according to Iraqi standards and specifications. Results showed microbial pollution by fecal Coliform bacteria in well water when using Using the agar media. Results showed the difference in the mean of (MPN) of well water. It was found that the EC value (1061) µs/cm was exceeded the permissible limit in W1, Cl values (325, 430)mg/l, pb values (0.43, 0.14) µg/l and Ni values (0.11, 0.11) µg/l and the permissible limit were exceeded in W1, W2 and SO4 values (681, 653, 584) mg / l also the permissible limit was exceeded in W1, W2 and W3 as well as Ag value (0.12) µg/l is in W1 only. The total risk index (HIT) in the groundwater for W1, W2, W3 was acceptable for adult values ƩHI (0.23, 0.97, 3.8E-4 ) and children values ƩHI (2.6E-2, 1.6E-2, 1.3E-3 ) respectively.

Keywords: Ground water, heavy metal, Microbial, Pollution.

1. Introduction

Groundwater is the water that has sunk through the layers of rain, rivers and fresh lake water on the earth at various depths and images, and since ancient times the amount of water in the globe has been fixed and does not change [1]. Groundwater, although often free from any bacteriological contaminations, require groundwater study and complete analyzes in the past allowing their use, And according to the geological composition of the soil, they reside in various dimensions of the surface area of the Earth to another. The importance of groundwater is increasing on an ongoing basis in particular, due to the growing demand for water for both agriculture purpose and industrial drink, the volume of groundwater exceeds the water of rivers and lakes significantly [2]. [3] Studied the Groundwater pollution in some areas between the Al-Kifl stream and the Shatt al-Hindi. The study relied on the collection and analysis of five models for selected areas of groundwater. The result was Hg [0.031]mg per l, Ni[0.01]mg per l, pb [0.068]mg/l, Cu [0.390mg/later Zn [0.171], Cd [0.002]mg per l. When compared with the Iraqi limitations for drinking water, it was found that it does not exceed the permissible limit. [4] studied trace element of groundwater contamination was measured in middle-class neighbourhoods of Lagos. Using atomic absorption spectrophotometers, approximately forty-nine well and borehole water samples were tested for their aluminum, cadmium and lead content.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd.
and their levels relative to the WHO maximum amount of pollutants. The results are [0.2, 0.003 and 0.01mg/L], respectively, for Al, Cd, Pb. Given the toxicity of these metals, the findings obtained from this study indicate a major risk to this population and the fact that for many, hand drilled wells and bore hole are really the only sources of their water supply in this area.

2. Methods

The methodology of this study divides into three main sections counting data set, data pre-processing, and hybrid machine learning model with the optimisation algorithm.

2.1 Well water samples

Three wells were chosen in the Aljaizer distreet of the Babel Governorate to study the microbial and chemical contamination in the water of these wells. 15 water samples were collected. Five samples from each well. The samples were placed in sterile glass bottles with a sealed seal and brought to the laboratory after being placed in a plastic box containing ice to preserve the samples and reduce microbial activity. And bottles of polyethylene for chemical trace elements characterized by [Pb, Ag, Cr, Cd, Ni] were estimated by (Atomic absorption spectroscopy) device, type shimadzu Japanese origin, model AA-700.properties, as samples were collected for the period from January to April [5].

2.2 Screening for coliform bacteria

2.2.1 Most Probable Numbers (MPN)

For middle user (FC Agar). A filter paper (sterile) is placed in the designated place in the filter unit. Transfer 100 ml of sample of the filter unit container. After finished from the filtered the filter paper is transported with sterile forceps and placed on the hardened agar surface (-M) FC agar pre-prepared without any voids. Leave the plate for a short period until the paper adheres well to the food medium, and this appears in the color Red filter paper. Incubate the dish up to 44.5 ° C for 24 hours and record the final result after 48 hours, according to the equation [6].

\[
\frac{N_{PM}}{100 \text{ ml}} = \left( \frac{N_{PM}}{\text{ml}} \right) \times (\text{from table} \times \text{dilution factor of } P2) \times 100 \hspace{1cm} (1)
\]

2.2.2 Physiochemical properties of well water were estimated, according to the methods given:

1. Ion exchang of water (pH), using meter-pH: It was measured directly in the field according to [7] by using (3540-pH-meter model). The instrument was calibrated before each sampling with standard buffer solution (pH: 4, 7 and 9).
2. Electrical conductivity (EC) using meter-EC: it measured directly in the field by using EC-meter(3540-pH-meter model). The instrument was supplied with an automatic temperature corrector. The results were expressed as µs.cm -1 according to [8].
3. Sulfate corrected with Na2-EDTA: It measured in the laboratory using the gravity burning method. Where 50 ml of sample were taken, adding dilute hydrochloric acid with a concentration of 0.1N, the mixture was heated to a boiling stage. Added to form 10 ml of barium chloride (BaCl2). The model is placed in a water bath at a temperature of 100 ° C for 15 minutes, then it is lifted, leaving for two hours to cool down, add to the form 3 ml of buffer ammonium and a small amount of aero chrome dye where the color becomes purple to blue and thus represents HARD2. Take 25 ml of the raw form and add to it 1 ml of ammonium puffer with a little dye of aero chrome and then wipe it with EDTA solution until the color changes to blue and thus represents HARD1 [9]. And also using UV-spectrophotometer at wave length 420nm [8].
4. Chlorides with silver nitrate correction method: It measured according to the (Mohr) method, which is the approved method for determining the chloride ion in contaminated water by the American health association. 50 ml of sample , and 1 ml of potassium chromate solution(0.0141N) as an indicator was added, the sample titrated against silver nitrate solution until convert the color from yellow to brown color [8].
5. Total suspended solid (TSS) by using the filtration method: The method approved by [9] was counted to estimate the total suspended solid, that’s by drying filter papers openings diameter of
0.45 micron, then the papers placed in the oven at temperature between 103-105 °C for one hour, cooled to room temperature in a glass bell, weighed by sensitive balance, Filter 100ml of sample.

6. Nitrates using the UV device: It measured using ultraviolet radiation with wavelengths of 220nm and 275nm with a spectrometer whereas the reagents were prepared. Reagents that were used (anhydrous potassium nitrate and hydrochloric acid). Standard solutions were prepared at concentrations of (0-350) micrograms from the nitrogen sample by diluting several volumes to 50ml with distilled water, which was (0, 1,..., 35) ml and adding 1 ml of 1N HCL, 220nm wavelength absorbance calculated.

7. Heavy metals characterized by [pb, Ag, Cr, Cd, Ni] were estimated by(Atomic absorption spectroscopy) device, type shimadzu Japanese origin, model AA-700.

3. Theory
3.1 Risk assessment
Risk assessment is the process for assessing risks related to environmental presence, fate as well as travel of chemicals. More specifically, risk assessment of environmental is an assessment of the risk for adverse effects from a chemical that is of concern to a site in order to identify the need for remedial action or to develop targeted levels where remedial action is needed. This includes the analysis of sources of release, mechanisms for chemical transport, and possible health risks to receptors. The Environmental Risk Assessment (ERA) includes an assessment of the risks associated with natural events (floods, extreme weather, etc.), technologies, practices, processes, products, factors (chemical, biological, radiological, etc.) and industrial activities that may pose a threat to ecosystems [10].

3.1.1 Chemical risks
Exposure is a contact with infected substance, such as persons or the endangered species. An exposure assessment is an estimate the exposure size, duration in addition to route of exposure frequency. The purpose of the exposure assessment is to estimate pollutant concentrations and dosages for at-risk populations [11].

The general chemical water intake equation is:

\[ MDI_i = \frac{C_w \times IR \times EF \times ED \times BW \times AT}{M} \]

Where the :
MDI: Maximum Daily Intakes (mg per kg. d ),
C_w: chemical concentration (mg/L) in water.
IR: rate (L/day) of inhalation.
EF: frequency of exposure(day/years).
ED: duration of exposure (year).
BW: the mean mass of the body over the exposure period (kg).
AT: average time; the time the exposure is averaged over (d).

3.1.2 Risk Assessment and Risk characterization
Risks for non-carcinogens are measured for all receptors that could be exposed to hazardous waste. Some general criteria include the measurement of risks for non-carcinogens for all types of exposure to hazardous chemicals (ingestion, inhalation and skin). A risk index (HI), which is the reference dose intake ratio, is measured as a non-cancer risk (RfD) [10]

\[ HI = \frac{MDI}{RfD} \]
Which:

HI = index of hazards (dimensionless).
MDI = Total intake per day (mg/kg.day).
RfD = (mg/kg.day) comparison dose.

In the strict sense of the term, this numerical value of HI, a risk and the measurement here is qualitative: a ratio of just under 1 means that a population exposed outside theory is hazardous, whereas a score greater than 1 means that a toxic effect will occur without estimating its likelihood [12]. In this assessment, three levels were considered to interpret the outcomes.

HI less than 1
HI equal 1
HI more than 1

The EPA sums the risk for each contaminant in a medium to account for multiple substances in one route:

\[ \text{Risk}_T = \sum \text{Risk}_i \]  (4)

The risk \( T \) = total risk
The hazard index multiple substances in one route is estimated as:

\[ \text{HI}_T = \sum \text{HI}_i \]  (5)

3.1.3 Microbial Risk Assessment

Risk assessment for FC in the ground water Calculated using the following equations [13] [14].

\[ \text{PI(}\text{infection/day}) = 1 - [1 + \left( \frac{d}{N_{50}} \right)^{-\alpha}] \]  (6)

\[ \text{PI (infection/day)} = (\text{PI (infection/ d)}) \times 365 \]  (7)

\( N_{50} \) = Average dose of infection equivalent to 8.60 \( \times \) 10^7
\( \alpha \) = Parameter of probability distribution function equivalent to 0.1778
\( d(\text{Ingestion dose}) = V \times C \)
\( V \) = Drinking water intake (2L/day).
\( C \) = Drinking water exposure, species per liter.

Infection is conditional on sickness, and the risk of being sick can be written as: [15].

\[ \text{P (ill/y)} = \text{PI (infection/y)} \times \text{S (ill per infection)} \]  (8)

Where:
\( \text{S (ill/infection)} \) is the germ’s degree of infectivity.
A value of \( \text{S (ill per infection)} \) given for diarrheal disease infection was assumed to be equal to 0.255 [16].
\( \text{S (ill/infection)} = 0.25 \).

4. Results and discussion

4.1 Microbial contamination of well water

The results showed the presence of microbial contamination, including coliform fecal, which is believed to be a cause contamination with these bacteria as a result of the different locations of these wells in which animal waste is abundant and as a result of this water being contaminated with animal waste or sewage water, because the group coliform bacteria, including the fecal coliform fecal, are naturally present in the intestine of humans and animals through which these microbes reach Waste to groundwater, and then the increase in numbers of these bacterial in waters of wells, and their presence in the water indicates the arrival of feces in any form to the water and its contamination.

4.2 Calculation of the most probable number of well water: (MPN)
The results showed a variation in the rate of the most likely number of well water for fecal coliform bacteria Table -1, as the rate of bacterial numbers was the water in well No. 1 was the most, amounting to $40 \times 10^3$ NPP/100 ml, while the lowest rate was in well No. 3, which was $22 \times 10^3$ NPP/100 ml. It is believed that the reason for the difference in number of bacterial in well water such as the result of a distance or proximity of the well to the sources of pollution and on the other hand it could be The difference in pH rates or different well water temperatures, the water temperature affects the viability of the water and promotes the growth of Pathological bacteria in it. As shown in Figure (1).

![Figure 1. Fecal coliform (FC) variations of the ground water.](image)

4.3 Physical and chemical and bacteriological groundwater analysis

The results shown in a table 1. Showed that physiochemical properties represented (pH, EC, TSS, Cl, SO4, NO3, BOD5, COD) in addition to five types of heavy elements (Pb, Cr, Ni, Cd, Ag) of the groundwater of the three wells. Through experimental work and its comparison with the Iraqi limits for drinking water, it was found that the EC value (1061) $\mu$s/cm had exceeded the permissible limit in W1 as shown in figure 3, Cl values (325, 430)mg/l, Pb values (0.43, 0.14) µg/l and Ni values (0.11, 0.11) µg/l were and the permissible limit were exceeded in W1, W2 as shown in figures (5, 10, 11 )and SO4 values (681, 653, 584) mg / l as well as the permissible limit was exceeded in W1 and W2 And W3 as shown in figure 6 as well as Ag value (0.12) µg/l in W1 only as shown in figure 14. The rest of the properties did not exceed the permissible limit. As shown in figures (2, 4, 7, 8, 9, 12, 13 ).
Figure 2. Ion exchange (pH) variations of the ground water.

Figure 3. Electric conductivity (EC) variations of the ground water.
Figure 4. Total suspended solid (TSS) variations of the ground water.

Figure 5. Chloride ion (Cl) variations of the ground water.
Figure 6. Sulfate ion (SO\textsubscript{4}) variations of the ground water.

Figure 7. Nitrite ion (NO\textsubscript{3}) variations of the ground water.
Figure 8. (BOD) variations of the ground water.

Figure 9. (COD) variations of the ground water.
Figure 10. Lead (Pb) variations of the ground water.

Figure 11. Nickel (Ni) variations of the ground water.
Figure 12. Chromium (Cr) variations of the ground water

Figure 13. Cadmium (Cd) variation of the ground water.
Figure 14. Silver (Ag) variations of the ground water.

Table 1. Results of the average concentration of the physiochemical, heavy metal and bacteriological characterization of the ground water in different locations.

| Parameters | Unit | Average Conc. For W1 | Average Conc. For W2 | Average Conc. For W3 | Iraqi allowable limit for drinking water 1967[17] |
|------------|------|----------------------|----------------------|----------------------|-----------------------------------------------|
| pH         | Unit less | 7.65 | 8.07 | 7.35 | 6.5-8.5 |
| EC         | µS/cm | 1061 | 796 | 739 | 1000 |
| TSS        | mg/l | 215 | 205 | 143 | - |
| Chlorides  | mg/L | 352 | 430 | 150 | 200 |
| SO₄        | mg/L | 681 | 653 | 584 | 400 |
| NO₃        | mg/L | 12 | 11 | 9.4 | 15 |
| BOD₅       | mg/L | 2 | 1.63 | 4 | <5 |
| COD        | mg/L | 53 | 41.8 | 21 | <100 |
| Pb         | µg per L | 0.43 | 0.14 | 0.005 | 0.1 |
| Ni         | µg per L | 0.11 | 0.11 | 0.002 | 0.1 |
| Cr         | µg per L | 0.03 | 0.02 | 0.004 | 0.1 |
| Cd         | µg per L | 0.01 | 0.01 | 0.001 | 0.1 |
| Ag         | µg per L | 0.12 | 0.02 | 0.001 | 0.1 |
| Fecal c.   | NPP per 100 ml | 40*10³ | 28*10³ | 22*10³ | 0 |

4.4 Chemical Risk Assessment

Table (2) shows the standard values that were used in an equation of max. daily intake of water. Exposure to heavy metal contaminants in ground water was measured by (2). While HI for non carcinogenic chemicals in ground water was measured by (3). And for the hazard index multiple substances used the equation (5).
Table 2. EPA Suggested values for intake estimation.

| Limit | The Standard value |
|-------|--------------------|
|       | Adult | Child (< 1.5 year) |
| weight of the Average body (kg) | 70    | 10    |
| Ingestion rate (L/day)           | 2     | 1     |
| Exposure duration (carcinogenic effect)(year) | 70    | 70    |
| Exposure duration (non carcinogenic) effect | 30    | 30    |
| exposure frequency (day/year)     | 365   | 365   |

Table (3) shows the results of the ingestion intake (MDI) and the hazard index (HI) for the heavy metal [pb, Ni, Cr, Cd, Ag] in the ground water. Where it's found that the total non-carcinogenic risk index (HI_r) in the groundwater for W1, W2, W3 was acceptable for adults and children.

Table 3. Calculated the ingestion intake of substances in the ground water and risk of threshold-effect substances.

| Substance | Max. Conc. (mg/L) | MDI (mg/kg.d⁻¹) | Oral RfD (mg/kg. day) | HI | HI |
|-----------|------------------|-----------------|----------------------|----|----|
|           | Adult | Child | Adult | Child | Adult | Child |
| W1        |       |       |       |       |       |       |
| Pb        | 0.84E-3 | 0.024 | 8.4E-5 | 0.006 | 4E-3 | 1.4E-2 |
| Ni        | 0.48E-3 | 4.8E-4 | 4.8E-5 | 0.02 | 6.85E-4 | 2.4E-3 |
| Cr        | 0.08E-3 | 8E-5 | 8E-6 | 0.005 | 3.8E-4 | 1.6E-3 |
| Cd        | 0.04E-3 | 1.14E-3 | 4E-7 | 0.0005 | 0.228 | 8E-3 |
| Ag        | 0.03E-3 | 8.57E-4 | 3E-6 | 0.005 | 1.71E-2 | 6E-2 |
| W2        |       |       |       |       |       |       |
| Pb        | 0.59E-3 | 1.68E-5 | 5.9E-7 | 0.006 | 2.8E-3 | 9.83E-5 |
| Ni        | 0.32E-3 | 9.14E-3 | 3.2E-5 | 0.02 | 0.457 | 1.6E-3 |
| Cr        | 0.05E-3 | 1.42E-3 | 5E-6 | 0.005 | 0.285 | 1E-3 |
| Cd        | 0.04E-3 | 8.57E-4 | 3E-3 | 0.0005 | 1.71E-3 | 6E-3 |
| Ag        | 0.04E-3 | 1.14E-3 | 4E-6 | 0.005 | 0.228 | 8E-3 |
| W3        |       |       |       |       |       |       |
| Pb        | 0.002E-3 | 5.71E-8 | 2E-7 | 0.006 | 9.52E-6 | 33E-5 |
| Ni        | 0.008E-3 | 2.28E-7 | 8E-7 | 0.02 | 1.14E-5 | 4E-5 |
| Cr        | 0.02E-3 | 5.71E-7 | 2E-6 | 0.005 | 1.14E-4 | 1E-4 |
| Cd        | 0.004E-3 | 1.14E-7 | 4E-7 | 0.0005 | 2.28E-4 | 8E-4 |
| Ag        | 0.003E-3 | 1.71E-5 | 0.005 | 6E-5 | 3.8E-4 | 1.3E-3 |

- EPA allowable limits: If HI ≥1: risk unacceptable else the risk acceptable.

4.5 Microbial Risk Assessment
Risk assessment for FC in the ground water, was calculated by using equation (6) and (7), and for the probability of becoming ill was calculated by the equation (8).
Table (4) shows the results of risk assessment of FC in groundwater. The average value of PI (infection/day) and P (ill/dose) does not exceed the EPA allowable limits.

Table 4. Risk assessment of FC in the groundwater.

| Location | FC cell/L | PI (infection/day) | PI (infection/year) | S (ill/infection) | P (ill/dose) |
|----------|-----------|--------------------|---------------------|------------------|------------|
| W1       | 40E3      | 2E-3               | 0.73                | 0.25             | 0.18       |
| W2       | 28E3      | 1.15E-4            | 4.22E-2             | 0.25             | 1E-1       |
| W3       | 22E3      | 9.09E-5            | 3.31E-2             | 0.25             | 8.29E-3    |

** EPA allowable limits: If PI (infection/day) and P (ill/dose) < 1×10^-6: the risk acceptable else the risk unacceptable.**

5. Conclusion

1. The result indicated that most of the physical, chemical, parameters did not exceed the Iraqi determinants for drinking water. In all wells chosen for study except for the EC value (1061) µs/cm only exceeded the normative parameters in W1 while chloride values (325, 430)mg/l exceeded the Iraqi determinants of water in W1 and W2, and also SO4 values (681, 653, 584) mg/l exceeded the determinants in all wells studied. And for the examining the heavy elements of groundwater showed that the Pb values (0.43, 0.14) µg/l and Ni element values (0.11, 0.11) µg/l were in the W1 and W2 exceeded the permissible limits, while Ag value (0.12) µg/l exceeded the permissible limit in W1 only, the other elements did not exceed the permissible limits.

2. The results showed that the total risk index in the groundwater for W1, W2, W3 was acceptable for adult values ΣHI( 0.23, 0.97, 3.8E-4 ) and children values ΣHI ( 2.6E-2, 1.6E-2, 1.3E-3 ) respectively.

3. For the microbial risk assessment, the mean annual incidence of PI infection (infection / year) caused by fecal coliform bacteria in groundwater and the risk of diarrhea due to infection caused by fecal coliform in groundwater (mean P (ill / dose)) Until it becomes spatial in the groundwater used for drinking. Where it was found that the ratio of PI(infection/day) values( 2E-3, 1.15E-4, 9.09E-5 ) and P (ill / dose) values ( 0.18, 1E-1, 8.29E-3 ) had exceeded the environmental determination allowable for EPA.

Reference

[1] Al-Madhlom Q, Al-Ansari N and Hussain H M 2016 Assessment of Groundwater Vulnerability in Northern Babylon Governorate, Iraq *Engineering* 8 883–902
[2] Modood T 1988 ‘Black’, racial equality and Asian identity *J. Ethn. Migr. Stud.* 14 397–404
[3] Hassan K 2016 Groundwater pollution in some areas between the Al-Kifl stream and the Shatt al-Hindi *J. Hum. Sci. / Coll. Educ. Humanit.* 23
[4] Momodu M A and Anyakora C A 2010 Heavy metal contamination of ground water: The Surulere case study *Res. J. Environ. earth Sci.* 2 39–43
[5] Devi R, Singh V and Kumar A 2008 COD and BOD reduction from coffee processing wastewater using Avocado peel carbon *Bioresour. Technol.* 99 1853–1860
[6] Amal Alghamdi 2016 Study, isolation and definition of microorganisms in drinking water samples. 492.
[7] Lee J, Durst R W, Wrolstad R E and JD C E T G M M H J H K S K D A K S M S K M B K M T C P F R A S G T U W 2005 Determination of total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method: collaborative study *J. AOAC Int.* 88 1269–1278
[8] APHA. (American Public Health Association) 2005 Standard Methods for the Examination of Water and Wast Water, Twentieth First Edition.
[9] APHA, AWWA AND WEF, 22nd ed. Washington: American public Health Association 2012 Standard Method for the Examination of water and wastewater
[10] Mohammad A.M. Al-Tufaily and Sabreen Lateef Kareem 2010 Risk Assessment Analysis Procedure to Control Pollution Problems in Euphrates Region in Iraq
[11] Richard J.Watts, 1997 Hazardous Wastes department of Civil and Environmental engineering, Washington state university, copy by John Wiley & Sons.
[12] Evens Emmanuel, Marie Gisèle Pierre , Yves Perrodin ,2009 Groundwater contamination by microbiological and chemical substances released from hospital wastewater: Health risk assessment for drinking water consumers journal home page : www. elsevier. com / loc ate / envint.
[13] Fewtrell, L. and Bartram, J., 2001 water Quality: Guidelines, Standards and Health Published by IWA Publishing, London, UK. ISBN: 1 900222 28 0.
[14] Bruce A. Macler a and Stig Regli 1992 Use of microbial risk assessment in setting US drinking water standards. International Journal of Food Microbiology, 18 245-256.
[15] Navier, D., Laroche, L. and Hartemann, P 2006 Waterborne Microbial Risk Assessment, Grenoble University Hospital, 38700 La Trochee, France, http://www.biomedcentral.com/1471-2458/6/122.
[16] Howard G and Pedley S 2003 Quantitative Microbial Risk Assessment for piped Water Supplies in Uganda Robens Center for Public and Environmental Health (University of Surrey_ https://www.researchgate.net/publication/221911472.
[17] WHO 1996 Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes. CRC Press.