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Review Article

WATER POLLUTION, LIMNOLOGICAL INVESTIGATIONS IN KURDISTAN REGION AND OTHER PART OF IRAQ

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Abstract: The main princples of sustaining the quality of water supply varies socially, politically, and culturally according to the locations and the beneficiaries. Cultural issues of water supply relate to the customs and beliefs of, and naturally its impact on, the ethnic groups supplied, while the social perception may relate to the users, beliefs, desires, and their expectations of the type of water systems available for different stakeholders in the society. A great number of liminological studies have been conducted on various water systems within the Kurdistan region.Generally, the physico-chemical parameters were as follow; pH ranged 6.5-8, TDS ranged from , EC ranged from 0.37-2050 , DO ranged from 0.0-12.8 mgl^{-1}, Nitrate 16-230 $N.NO_3\ l^{-1}$, Nitrite up to 1.4 $N\text{-}NO_2.l^{-1}$, chloride 0.02-0.06 $meql^{-1}$, hardness 3.64-286 $mgCaCO_3.l\text{-}^1$, reactive phosphate 0.28-12.7 $P\text{-}PO4.1^{-1}$, respectively. Also, in the rest of Iraq, the physico-chemical variables were as follow; pH ranged from 6.8-8.2, TDS ranged from 122-540 mgl^{-1} , Na, 35-95 mgl^{-1}, K ranged from 1.4-2.2 mgl^{-1}, chloride ranged from 35-165 mgl^{-1}nitrate value 46-300 as $N.NO_3\ l^{-1}$ and nitrite from 1.4-3.6 $N\text{-}NO_2.l^{-1}$, alkalinity and reactive phosphours value ranged 5.4-29.6 $meq.l^{-1}$ and 10-26 $P\text{-}PO4.1^{-1}$, respectively. Also heavy metals such as Cd, Fe, pb, and Zn were ranged 0.007-0.058, 0.01-0.130, 0.002-0.061, and 0.040-0.320 mgl^{-1}, respectively.

All in all, according to Water Quality Index (WQI), most of the water sources requires primary treatment before use for drinking, whereas waters of Tanjaro river and Qiliasan stream cannot be used for drinking till they are treated (primary to tertiary treatments).

Keywords: Point and non-point sources, ground water,Kurdistan.

Introduction

Environmental impact of water

Environmental consideration is as significant as other commodities. The potential source of the water suppy and its ability to supply the entire population are important factors to be taken into consideration. Furthermore, environmental consequences may occour especially where large amounts of bored wells are pumped which may have some implications (Ndege, 2001).

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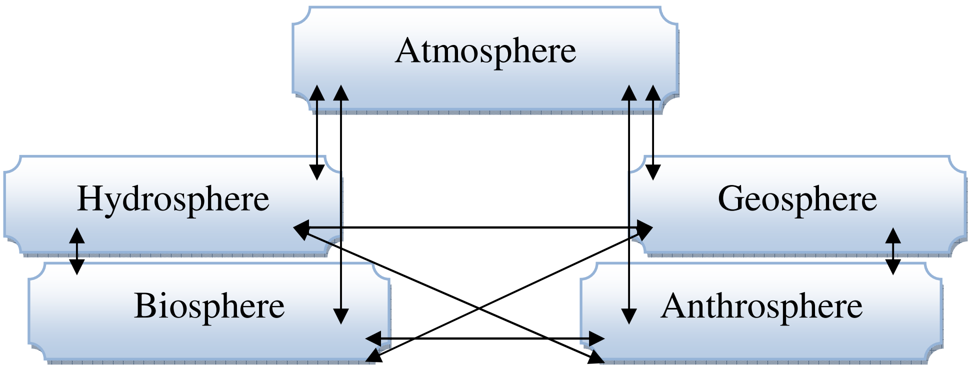
Hydrological cycle

Water movemet between the earth (Geosphere) and the atmosphere through different reservoirs or Components, (atmosphere, hydrosphere, biosphere and androsphere), is illustrated in figure, 1.

When the sun heats seawater, it evaporates and becomes water vapor which then rises in the atmosphere, condenses and forms precipitatioon such as rain. Eventually it falls on the land and starts its journey via glaciers, creek and rivers whilst some evaporates from the surface of the vegetation and soil, or is soaked into the ground water where it gradually evaporates or is used by vegetation. This cycle is known as the hydrological cycle (DLWC, 1995). Depending on their locations these reservoirs are seen to have common interactions.



From: Eyre, 1993; DLWC, 1995; Ambient, 2001.

Figure (1): Transfer of water within major reservoirs

Atmosphere

The atmosphere is largely transparent to long-wave solar radiation but absorbs most of the radiation emitted from the surface of the earth. Its behaviour is particularly influenced by the presence of clouds, which strongly affects both incoming and outgoing radiation (Australian Bureau of Meteorology, 1993).

Furthermore, atmospheric water vapor and carbon dioxide (even though in small amount) produce green house effects which keep the temperature at the earth's surface in the range within which complex life forms can exist. On planets such as Venus, with much greater levels of carbon dioxide (CO_2), the much stronger green house effects produce temperatures too high to maintain life (Australian Burea of Meterology, 1991 and 1993).

Hydrosphere

It represents 1.41 billion cubic kilometers of water in the world, only 2% of this volume is fresh water and most of the fresh water is stored in glaciers, ice caps, and in deep ground

(Australian Bureau of Meterology, 1991 and 1993; Eyre, 1993; DLWC, 1995).It has been estimated that about 40 000 Km^3, only 2% of this volume is accessible in lakes, rivers and ground waters (Australian Meterology Bureau, 1991 and 1993).

Biosphere

The biosphere refers to the living and dead organisms in the environment, particularly terrestrial vegetation and the phytoplankton in the upper ocean (Australian Bureau of Meterology, 1991 and 1993).

Geosphere

The geosphere consists of the solid land surface (Lithosphere), the oceans, rivers, and inland water (the hydrosphere) and the continental ice sheets, glaciers, sea ice, snow and permafrost (the cryosphere) (Australian Bureau of Meteorology, 1991 and 1993; Eyre, 1993; DLWC, 1995; Ambient., 2001).

Availability of water

It is perhaps, also important to note availability of water in the biosphere (Howell,1993; Allenby et al., 1993). It is suggested that water varies across the earth both in terms of quality and quantity (defined by concentration of dissolved solids ,suspended solids and organisms) (Howell, 1993). While the availability of water exists, the ecosystem (i.e. plants, animals and living organisms) utilizies it, but for human needs, modification of water is necessary. The destruction, especially of shallow riverine and costal aquifers through over pumpimg and pollution is greatly adding to the water crisis now experienced by many areas in the Asia-Pacific region (UNEP, 1996).

Water related issues

Ina general, the availability of water depends on the location and climatic natureof the region (Alenby et al., 1993). Many factor that reflect on the nature of the water resources. The importance of water depends on the availability, quantity and the quality of sourced water in order to fulfill desired requirements. Detailed below is how some of the background and overviews of water related issues which are experienced throughout the world (United Nations, 1997).

Water Pollution

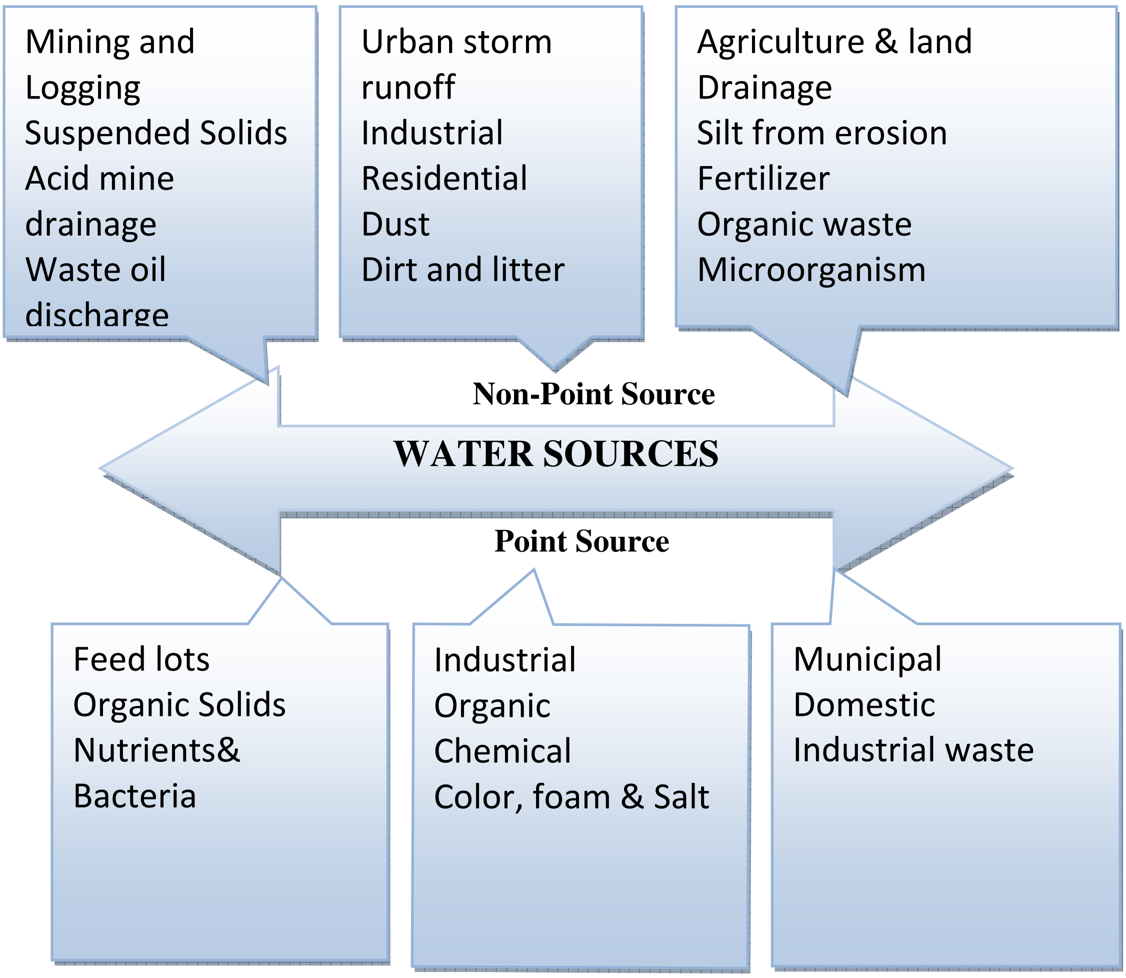
The pollution of water sources happenes through point and non-point source pollution (figure,2). Non-point source pollution is more ambiguous which cannot be related to a specific point for example, pesticides and fertilizers application to agriculture fileds (Allenby et al., 1993; Viste et al., 1994; Hammer et al., 1996; Nathanson, 1997).

The characters of point source water pollution is that;

1) Pollution can be accurately determined.

2) Limited real extent (e.g.; contaminants introduced into water sources from the discharge of effluent from industries, septic tanks and leachate from landfill through waste discharges from public waste water treatment plants).

The problem of water pollution occurs when substances are added to the water that affect its chemical composition and threaten the human health and ecosystem (Allenby et al., 1993). Agricultural land, sewage effluent, debris, runoff from urban areas, and animal waste, are found to be responsible for the increased number of microorganisms found in water (Allenby et al., 1993; Berka et al.,1995; Boyd, 2000). In addition to chemical pollution the ground water quality can be further endangered through increasing levels of parameters affecting water quality such as, hydrogen ion concentration (pH), electrical conductivity (EC), turbidity, and microbiological content (WHO,1993).



Figure(2): The sources of water pollution

Bore wells

Ground water sources differ from other natural water sources in that the hydrologic cycle and hydrosphere are two inextricably bound systems with each of them constatly exering an influence over the other (Howell et al., 1993; Eyre et al., 1993). Ground water is described as water that is found underground in the saturated zone of rock i.e. at depth where the entire void of spaceof the rocks is filled with water (Allenby et al., 1993 ; DLWC, 1995). Ground water quality is of higher standard compared to surface waters because of its natural purification. Less treatment is required where minimal treatment is a high priority (Reinhold, 1992).

Bore wells are also popular in many of the rural communities in both developed and developing countries especially where the supply of treated tap water may not be feasible (SIA, 2000). It is primarily used for domestic consumption, agriculture, and industrial activities. The application and usage depends on the nature and quality of the source. (NDOH, 2000).

Ground water contamination

Ground water contamination by microorganism, point source and non-point source is a serious pollution problem in many countries in the world (Hammer et al., 1996; Tomar, 1999; Boyd, 2000).

There are a number of routes by which ground water is contaminated:

- ❖ Inter-aquifer leakage and irrigation returns (Reinhold, 1992; Hammer ***et al***., 1996).
- ❖ Leached from soluble solids at the surface and leaking from broken sewer pipes or lines (WHO, 1993).
- ❖ Percolation of liquid sprayed over land (Beckett, 1993).
- ❖ Land fill leachate (Blight, 1995).
- ❖ Septic and sewerage effluent discharge (Boyd, 2000).

Ground water contamination by chemicals such as cobaltwas reported in Bangladesh (Hueb, 2001). The (20%) had heigh levels of cobalt above $0.05 mg.l^{-1}$, after of the 25 000tests on wells carried out in Bangladesh, which is contrany to the WHO (1993) drinking water quality guidelines (Merit et al., 1997) evaluated water quality, they reported that the high levels of calcium and magnesium occurred in aquifers found in limestone bedrock.

The nature aquifer that provides the deep well is free from contamination a pollution case is indicated cracked, faulty well casings, open well caps and spills from neighboring source are found to be responsible for such incidences (Merit et al., 1997).

Nitrate contamination of ground water

The inorganic contamination of greatest concern in ground water is the nitrare ion , which commonly occurs in aquifers near rural and suburban population. Although uncontaminated ground water generally has nitrate nitrogen levels of less than 2 ppm, nitrate in ground water originates mainly from four source:

- Application of nitrogen fertilizers, both inorganic and animal manure to cropland.
- Atmospheric deposition.
- Humman sewage deposited in septic systems.
- Cultivation of the soil.

For example, almost 12 million tons of nitrogen are applied annually as fertilizer for agriculture in the United States, and manure production contributed almost 7 million tons or more. In most cases, the reduced forms of nitrogen was oxidized in the soil to nitrate, which then migrates down to the ground water, where it dissolves in water and is diluted because nitrate removal from well water is very expensive, water contaminated with high levels of nitrate normally is not used for human consumption, at least in public-health (Barid and Cann, 2005).

Jennings et al., (1998) undertook a study on toxicity of nitrate in ground water, they showed that among infants less than one -year old, pregnant women, and persons of all ages with reduced gastric acidity or hereditary lack of met hemoglobin reductase, those most at risk for exposure are those who according to shallow wells foe drinking water.

Reddy and Lin, (1999) conducted an investigation about nitrate removal from ground water using catalytic reduction process to selectivly removing nitrate ion from ground water, associated with agricultural community. Three catalysts used were, palladium, platinum, and rhodium.

The transport of nitrate in a ground water aquifer in relation to age, landuse practies, and redox processes in west-central, Minnesota was investigated by (Puckett and Timothy, 2001). They found that nitrate concentrations were heigh, behaved like oxygen, decreasing with both increasing age and depth, suggesting that once O_2 was depleted, nitrate was utilized as the terminal election acceptor in the oxidation of organic carbon. Rosen et al., (2004) investigated a prediction of ground water nitrate contamination after closure of an unlined sheep feedlot in Carson city, United States.

Bacteria spread in ground water

Ground water is held in the pore space of sediments such as gravels or sands or in the fissures of fractured rock such as limestone. The sediments or rock contain the water defind as an aquifer and the upper water level in the saturated body, which is defind as the water table (Moss, 2003).

Recently, several theories concerning the movement of bacteria in ground water showed that the bacteria tend not to travel along distance in fine soil but can travel very long distances in coarse soils particle or fractured formations (Bourwer H, 1978 andReinhold, 1992). Surface water, which may carry pathogenic organisms in aquifer systems from sewage discharge, landfill leachate and polluted water, landfill leachate, and sewage discharge (Berka, 1995; Boyad, 2000).

In ground water growth of bacteria occurs within the optimal potential hydrogen range between 6.5-7.5, which is close to the intracellular hydrogen (Clark et al., 1989). Apparently only few species can growth at a value of potential hydrogen less than two or more than ten (Brock, 1979). Many studies have prepared reports indicating that a toxic environment is unavailable and donot contribute to the growth of microorganisms (Brock, 1979). The toxicity of the environment refers to many factors sush as, sound and radiation, hydrostatic pressure , high and low temperatures (Reinhold, 1992). The activity of most enzyme, protein synthesis and membrane transport relatively contribute to enhance the microbial growth is some times affected by hydrostatic pressure at 200-600 atmospheres, but they grow well at atmospheric pressure in soil or shallow water (Reinhold, 1992).

Ground water and health

Hisorically, ground water has been a source of high quality and relatively clean, drinking water, needing little if any or no treatment (Reinhold, 1992), however surface water has usually requires some treatments as a result of ever increasing human interactions, through agriculture, sewage, disposal, industries, aquaculture and other activites.

Water quality and public health

Water quality and public health are linked in many ways (Brudtland, 2001). Safe and potable water is essential for human life (Michiels et al., 2000). Many theories have suggested that water was responsible for transmission of many waterborne diseases through the microbial contamination of drinking water, which is the most critical risk factor in potential widespread of disease. It continues to be a major cause of morbidity and mortality (UNEP/WHO, 1996).

Despite worldwise efforts and the availabilty of modern technologies utilized for the production of safe drinking water, it has been reported that the transmission of waterborne disease is a matter of major concern (Stevens et al., 1995). The contamination of drinking water during storage, a lack of regulations and limited understanding and awareness among the population is documented (Mackenzie, 1994; Roefer et al., 1996). The adverse implications of mechanical failure, human error or deterioration in the quality of the source water, even with the best treatment system and disinfection process, can sometimes degrade the water quality (Mackenzie, 1994; Roefer, 1996; Geldreich, 1996).

Diseases derived from chemical contamination of drinking water are negligible compared to the number due to microbial contamination (Herwaldt et al., 1992). High chemical concentration in drinking water can pose a health risk; however, in the case of bacteria contamination a presence of only small numbers many cause a health risk to the consumer (WHO, 1997). Epidemiological studies have shown that poor water drinking quality (referred to feces and environmental contamination or un-chlorinated water) as the major transmission route, was responsible for many of the waterborne diseases (Lee et al., 1993). Examples of these transmission routes for waterborne disease to humans are;

1. Consumption of untreated, inadequately treated, or contaminated water directly or inddirectly through food preparation.
2. Body contact with contaminated waters for example,fresh water, marine water, swimming pool.

Global examples of waterborne disease

Epidemics of cholera have beenreported in England (Weinstien, 1980) and Peru (Gray, 1994; Putnam and Wiener, 1995). Diarrhoea, typhoid and dysentery are common in many part of Papua New Guinea (NDOH, 2000). The most affected are children and the elderly people. Amajor outbreak of E.coli (0157) was reported in a small town of Walkerton, Ontario about 180 Km north of Tornto causing 7 fatalities, mainly the elderly people, and leaving several people in a serious condition (Health Stream, 2000). The incidence of diarrhoea disease caused by drinking contaminated water in Fujian province, south east of China has been reported (Chen et al., 1991). It was noted that the number of instances per year of people suffering from diarrhoea due to drinking contaminated water was 575.00 per 1000 persons in people drinking reticulated water, 846 per 1000 people drinking well water and an astounding

4567 instances per 1000 peoeple per year drinking river water. Poor saintary conditions, overcrowding <10 square meters per person and low income are some of the significant indicators which contribute to factors causing diarrhoea (Chen et al., 1991). The relationship between microbial quality of drinking water from different sources, and the prevalence of diarrhoea disease among children under two years was studied in Cebu, Philippines (Moe et al., 1991). The percentage of different wells investigated yielding greater than 1000 coliforms per 100ml were; 21% of 123 spring water wells, 21% of open dug wells, 14% of 52 wells with pumps, 6% of 75 boreholes and 60% of5 non-municipal reticulated tap water supplies. The microbial were studied in all the water sources (Moe et al., 1991).

The immense risk of gastroenteritis disease among the elderly, young, pregnant woman, and those whose immune systems are compromised by cancer, and AIDS (Acquired Immune Deficiency Syndrome) was investigated (United State Environmental Protection Agency, 1993; Payment et al., 1997).

Limnological lnvestigations in Kurdistan region

It is clear that, numerous limnological studies were carried out on various water systems within the of Kurdistan region. But in general, it can be said that the first ecological investigation in Iraq dates back to many papers prepared by German group led by (Kolbe and Krieger, 1942).

These investigations consist of ninethy-seven collections from eleven locations carried out by Handel Mazzetti's expedition to Iraq and Turkey around Euphrates and Tigirs, it recorded 248 taxa of diatoms from fresh and brackish water habitats.

One of the important investigation on different well waters in Sulaimani province was conducted by Anon (1957). He showed a detail information for different well waters, by examing the water samples for several physical, chemical and bacteriological testes. The mean value of water tempreature was 19.5 °C, potential of hydrogen ion value ranged between 6.7 to 7.71, electrical conductivity value ranged from 0.37 to 1.150 $mhos.cm^{-1}$. While the mean value of alkalinty as $CaCO_3$ between 2 to 6.4 $meq.l^{-1}$, concentration of dissolved oxygen ranged from 2.37 to 8.8 $mg.l^{-1}$. The mean value of biological oxygen demand for five days of incubation under 20ºCdid not exceed 0.81 $mg.l^{-1}$. Nitrate concentrations revealed that all the wells water were found to be suitable for irrigation purpose.

Ecological studies in Iraq developed with developing universties and scientific centers, therefore from beginning of 1970s on word many papers have been puplished in Kurdistan region (Antoine, 1977and Hameed, 1978). They were almost restricted to aquatic and marine ecology. Limnologically, phycologically, and oceanographically considerable areas of these water bodies. Made a comprehensive ecological survey for Iraqi inland waters, have been studied by (Islam and Hameed, 1985).

The initial limnological studies on the water quality in Iraqi Kurdistan region started at Sulaimani province by Maulood and Hinton (1978). Some dissertations have been produced in Sulaimani University which have a great role in limnological study in Iraq. In Kurdistan only a few post graduated students dealed with limnological studies in various aquatic ecosystems. It is clear that water systems cover a wide range of Kurdistan area, they include surface water, ground water, wells, Kahreeze, spring, lake and impoundment in one hand, channel, tributaries, river on the other hand. Results of various investigation shows the presence of mineral water, sulfer spring, stenothermal and eurythermal water system. The variation in their chemical and physical properties in various area have been dealed by many authors and investigators.

EL-Yossif and Al-Najim, (1977), studied the hydrology and quality of Serchinar spring water. They provided that mean value of potential hydrogen ranged from 6.95-7.39, electrical conductivity values ranged from 500-680 $\mu S.cm^{-1}$, chloride from 0.02-0.06 $meq.l^{-1}$, whereas the mean value of calcium concentration ranged from 0.40-0.39 $meq.l^{-1}$, and magnesium values ranged from0.40-4.72 $meq.l^{-1}$. Maulood and Hinton, (1979) estimated that trace elements content of Sarchinar spring was higher than of water of Killiassan river but, never reached the toxic level.

Kamees (1979) studied the ecology of water pollution in Tanjaro valley which is fed by Chaqchaq river and Sarchinar spring. He studied the assessment of water quality. However, Al-Shahwani, (1980) studied the primary productivity of Sarchinar spring.

The study on the chemical status of drinking water in Sulaimani city in investigated by Al-Shahwani (1980). The water of Sulaimani from it is principal sources was analyzed monthly throughout years. The value of total hardness ranged from 110-286 $mg.CaCO_3.l^{-1}$, calcium hardness ranged from 28-70 ppm, while the magnesium hardness ranged from 0.0-35 ppm.

Ibrahim, (1981) conducted a study on some physico-chemical properties and phycological studies of thirty-seven springs at different regions within Sulaimani province. Only three springs from the total were thermostatic with a temperature fluctuation ±1°C around annual mean temperature, while the lowest and the highest temperature were recorded in Balkian and Khurmal springs which were 12.8C° and 29.5C° respectively. The potential of hydrogen values were generally >7.0 witin an over all mean of 7.28 for all sources, the electrical conductivity values were ranged from 226-2050 µS.cm^{-1}, reactive phosphorus ranged from 0.28-12.7 µg at P-PO_4^{-1}, and alkalinity148-352 mg $CaCO_3$.l^{-1} On the other hand nitrate ranged from (16.1-275 µg at N-NO_3^{-1}, nitrite ranged from 0.0-0.81 µg at N-NO_2^{-1}. Calcium and magnesium concentrations were ranged between 50-361.2 mg.l^{-1}, and 4.1-34.1 mg.l^{-1} respectively, the value of dissolved oxygen ranged from 0.0-12.8 mg.l^{-1}, biological oxygen demanded for five days ranged from 1-5 mg.l^{-1}.

A study on water and soil pollution in Sulaimani city investigated by Khorshid (1981). He selected seven various wells. It is found that the temperature of the studied well waters did not vary greatly, the changes in temperature did not exceed 2Cº, the mean potential hydrogen ranged from 6.7-7.7,where as the mean alkalinity ranged from 2.0-6.4 meq $CaCO_3$.l^{-1}, while the mean of electrical conductivity values ranged from (0.37-1.15 mmhos.cm^{-1}. The mean values of biological oxygen demanded for five days under incubation at 20 Cº was 2.0 mg.l^{-1}, it is clear that all the well waters were very clean in relation to BOD_5 values. Morover the mean values of nitrate ranged from 49-230.5 µg at N-$NO3^{-1}$, while the mean value of nitrite concentration was 1.4 µg at N-NO_2^{-1}, total hardness ranged from 3.64-10.74meq $CaCO_3$.l^{-1}. All the well waters were similar in their content of total bacteria count, coliform and fecal coliform, but their numbers varied among themselves. The organic matter percent and total nitorgen increased in the soils after irrigation. However the available phosphorus and potential hydrogen values decreased in the soils after irrigation.

A study on diurnal variation of some physical and chemical charactristic of Sulaimani well water was conducted by Khorshid (1988). seven wells wereselected at various locations. It was observed that diurnal variation would be influenced by specific well location, well depth, and the water‘s specific properties.

Muhammad (2004) studied the aquatic life in Sarchinar spring, Chaq-chaq and Kliassan streams within Sulaimani city. Water samples were collected at fortnight interval peroids from ten various water resource sites. He indicated that the hydrogen ion concentration of the all studied areas were on the alkaline side of neutrality. Alkaline waters ranged from 102-340 mg. $CaCO_3$.l^{-1}, water hardness ranged between moderately hard to very hard waters 110-355 mg $CaCO_3$.l^{-1} within low or saturated by oxygen 1.00-9.00 mg.l^{-1} and healthy situation with regard to biological oxygen demand for five days under incubation at 20ºC 0.20-9.50 mg.l^{-1}. In all investigated sectors, cations were dominated by calcium followed by magnesium, sodium and potassium with decreasing their concentrations in order.

Ganjo and Toma (2004) conducted a limnological investigation on vertical profile of Dokan lake, water samples were analyzed for five days in May 2000. The ecological variables determined : potential hydrogen in epilimnion were on the alkaline side of neutrality, electrical conductivity values were moderately high.

Mustafa (2006) made a study impact of sewage waste water on the environment of Tanjaro river and its basin with in Sulaimani city, and he reveled that as a whole, Tanjero river, Qiliasan stream and ground water of the area were polluted with sulfate, nitrate, nitrite, ammonia, ammonium and heavy metals (Cadmium, Cupper, Nickel, Lead and Zinc). Moreover according to Water Quality Index (WQI), ground water requires primary treatment before use for drinking, whereas waters of Tanjaro river and Qiliasan stream cannot be used for drinking till they are treated (primary to tertiary treatments).

On the other hand, quite many dissertation and papers on regional limnological and bacteriological studies on ground water have been published in Salahaddin University during the two decades.

General survey of Hawler ground water area has been conducted by Hadad et al., (1974), they concluded that the area of Hawler is relatively well endowed with good aquifers containing water of quality generally suitable for drinking and irrigation purpose.

A bacteriological study on twentey well waters of Hawler, Kirkuk, and Sulaimani was carried out by Abdul-Rida (1981). The water samples were analyzed for the following parameters: total bacterial count that revealed a minumum of 100 cell/cm^3 to maximum of 260 000 cell/cm^3, while potential hydrogen of the investigated wells were in the alkaline side of neutrality, chloride concentrations ranged from 4.0-237 $mg.l^{-1}$, and biological oxygen demanded for five days ranged from 0.1-4.5 $mg.l^{-1}$.

A limitation of some ground water suitability in Hawler plain for different uses was conducted by Esmail (1986). Eleven wellls were using during the growing seasons(1984-1985) in the experiment; the electrical conductivity values ranged from 0.9-8.9 $mmohs.cm^{-1}$.

In (1994) Rasheed conducted a limnological study on some various water systems containing Karezes, springs, impoundments, and streams, within Hawler province. He indicated that the value of potential hydrogen of the water system ranged from neutral to alkaline, electrical conductivity ranged from 173-1570 $\mu S.cm^{-1}$, total hardness ranged from 144-958 $mg.CaCO_3.l^{-1}$, moreover dissolved oxygen levels exceeded saturation levels, and reactive phosphours ranged from 0.02-16.21µg at $P\text{-}PO_4$.

Furtheromre, Al-bayathi et al., (1994) made an assessment quality of ground water wells belonging to Wdi-Lilan basin, in southeast Kirkuk. He analyzed nine sample well waters for their physical and chemical characterestics, and showed that most of the studied water wells except three wells were available for drinking purposes because of undesirable concentrations of hydrogen ion concentration values which were higer than 7.0 in all studied wells, electrical conductivity values ranged from 7.0-1880 $\mu s.cm^{-1}$, total hardness values ranged from 225-914 ppm, and total dissolved salts ranged from 415-1273 $mg.l^{-1}$.

Ganjo (1997) conducted a study on Ruwandiz river basin. He stated that the basin carries moderate amount of sewage and considerable levels of soil originated substances through out erosion loads when rainfall enters the refuse within the catchment area.

Dohuki (1997), caried out a limnological study monthly for a year on some water systems such as, wells and spring, to estimate water quality for drinking and irrigation purpose within Dohuk city. He observed that the electrical conductivity of water in these studied areas ranged from 0.47-2.57 $dS.m^{-1}$, 268-1513 $meq.l^{-1}$ for total hardness, 2.56-24.92 $meq.l^{-1}$ for calcium concentration, 1.6-45.44 $m.eq.l^{-1}$ for magnesium concentration, 0.3-3.8 $meq.l^{-1}$ for chlorocity, 0.01-25.3 $meq.l^{-1}$ for sulfate.

The WHO and Minestry of Health (1998) conducted a survey on physico-chemical and bacteriological drinking water source in Hawler governorate. The potential hydrogen values always were above 7.0, while concentrations of calcium, sodium, potassium and total dissolved solid ions ranged btween 18-55 $mg.l^{-1}$, 3.0-33.5 $mg.l^{-1}$, 0.6-3.0 $mg.l^{-1}$ and 100-424 $mg.l^{-1}$ respectively.

Hassan (1998) investigated the urban hydrology of Hawler basin ground water aquifer. After taking samples from thirty-five wells, he analyzed for physical and chemical characteristics. Water temperatures ranged from 19-22.5C°, electrical conductivity ranged between 330-1685 $\mu S.cm^{-1}$, total hardness between 117.5-669.9 ppm, the concentration of calcium ion ranged from 24-127 ppm, while the concentration of magnesium ion ranged from 1-40 ppm. Moreover total dissolved solid ranged from 230-1179 ppm, chloride ion from 10-106.4 ppm, nitrate from 0-30 ppm, sodium from 6.5-58 ppm and potassium from 1-14 ppm.

The WHO had a huge role via investigating a survey on assessment quality of drinking water sources in Erbil, Sulaimani and Duhok cities in Kurdistan. They investigated that most of water sources were within WHO guidelines for chemical and bacteriological contamination According to WHO guidelines the state percentage of contaminated samples must be under five percentage to define water as safe. They revealed that 11% of the sample (mostly water wells) taken from urban area in Hawler was contaminated bacteriologically, 20% and 40% of water samples respectively taken from semi-urban and rural locations of Hawler governorate were also bacteriologically contaminated.

Shekha, (2001) carried out a study of assessment quality of ground water within Hawler province by selecting forty-four wells and studied only one trial. All well water samples were analyzed physically, chemically and bacterologicaly, the parameters of the studied sites were as follows; value of hydrogen ion potential ranged from 7.08-7.97, electrical conductivity values ranged from 214-540 µS.cm^{-1}, with a high level of total hardness, furthermore, the value of nitrate, reactive phosphous, dissolved oxygen and biological oxygen demanded for five days under incubation were 0.21-42.9 mg.l^{-1}, 0.16-0.97 mg.l^{-1}, 5.2-12.1 mg.l^{-1}, and 0.4-7.2 mg.l^{-1} respectively.

In 2002 Al-Naqishbandi published limnological and phycological studies on some various water systems at Duhok province such as spring and impoundment and it is catchment area by selecting forteen sampling sites. He studied some physico-chemical variables of water samples, concluding that air temperatures ranged from 4.5-46 Cº, electrical conductivity of them ranged from 767-2560 µs.cm^{-1}, reactive phosphorous, dissolved oxygen, nitrite and nitrate were 0.172-5.363 µg at P-PO4.l^{-1},0.112-1.442 µg at N-NO_2.l^{-1},0.29-147.64 µg at N-NO_3.l^{-1},respectively.

Chnaray (2003), made a hydrological and hydro-chemical study on Kapran basin of Erbil city, involved ninetheen well water samples, the results of physico-chemical parameters as follow: the temperatures ranged from 18.8-23.5 Cº, hydrogen ion potential from 6.85-7.86, however total hardness, calcium hardness, magnesium hardness, total dissolved solid,and chloride ranged from, 135.48-306.93 mg.l^{-1}, 34.7-80.4 mg.l-^{1}, 10.5-26.5 mg.l^{-1}, 271-481 ppm and 2.5-30.8 mg.l^{-1} respectively. Reactive phosphorous ranged from 0.00-0.31 mg.l^{-1}, dissolved oxygen, biological oxygen demanded for five days, nitrate and sulfate ranged from 0.8-3.26 mg.l^{-1},0.00-1.21 mg.l^{-1}, 5.2-57.2 mg.l^{-1} and 12.2-121.73 mg.l^{-1} respectively. However, Aziz and Ganjo (2003), conducted a study on water quality of spring and small ponds at Halgurd mountain area in Kurdistan at an altitude (2800-3728 mas1). The results showed that water temperature never exceeded 4.7 Cº and air temperature was around15 Cº, dissolved oxygen ranged between4.1-5.4 mg.l^{-1}, total hardness, alkalinity, electrical conductivity ranged between 93-122 mg$CaCO_3$.l^{-1},117-136 mg$CaCO_3$.l$_{-1}$, and 156-198 µS.cm^{-1},respectively. The potential hydrogen was slightly alkaline, nitrate, reactive phosphours, and reactive slica were ranged from 12.7-21.2 µg at $N\text{-}NO_3.l^{-1}$,(0.12-0.65 µg at $P\text{-}PO_4.l^{-1}$, and 45.6-67.6 µg at $Si\text{-}Sio_2.l^{-1}$ respectively.

Moreover, Bilbas (2004) carried outa limnilogical and phycological investigation of twenty springs within Erbil province. He showed that the range of ecological parameters were as follow: 6.4-8.6 for hydrogen ion potential, 10-22.5 Cº for water temperature, (100-2180 mg $CaCO3.l^{-1}$ for alkalinity, 0.27-330 $mgCaCO_3.l\text{-}^1$ for acidity, 70-1560 $mg.l^{-1}$ for total dissolved solids, 22.6-275.7 µg at$N\text{-}NO_3.l^{-1}$ for nitrate, 37-440 $mg.l^{-1}$ for sulfate, 3.99-126.7 $mg.l^{-1}$ for chloride, 0.00-12.0 $mg.l^{-1}$ for dissolved oxygen, 0.00-13.00 $mg.l\text{-}^1$ for biological oxygen demanded under incubation situation at 20 ºC for five days.

Bapper (2004), conducted a phycological and limnological study on various water resources within different sites of Erbil province. Water resources which were under the study belonged to fifty-seven locations which included streams,wells, karezes, springs, ponds and water impoundment. The physico-chemical variables were determined as follow: hydrogen ion potential values above 7.0, higher value of electrical conductivity were recorded, which reached to 1809 $\mu S.cm^{-1}$ in pond near Suse. Alkalinity of the all studied water samples are 164-777 $mg.CaCO_3.l^{-1}$, acidity value ranged from 7.273-7.542 $mg.CaCO_3.l^{-1}$,dissolved oxygen ranged from 1.30-10.95$mg.l\text{-}^1$, biological oxygen demand for five days ranged from 0.01-10.0 $mg.l^{-1}$, chloride from 0.76-90.39 $mg.l^{-1}$, reactive phosphorous, nitrate, nitrite ranged from, 0.05-6.59 µg at. $P\text{-}PO4.l^{-1}$, 3.57-43.0 $mg.l^{-1}$ and 0.011- 45.5 µg at $N\text{-}NO_2.l^{-1}$, with highest dgree of water temperature reached to 31 Cº.

Nabi (2005) conducted a limnological and bacteriological study on some well water within Erbil city. He analyzed fifteen well water samples for their physical, chemical and bacteriological properties, and the ranged of parameter as follow: hydrogen ion potential ranged from 6.8-7.6, electrical conductivity values were btetween 380-1130 $\mu S.cm^{-1}$. Whereas, dissolved oxygen concentrations were 1.0-6.0 $mg.l^{-1}$,biological oxygen demand ranged from 0.2-2.6 $mg.l^{-1}$. Total alkalinity ranged from 96-410 $mg.CaCO_3.l^{-1}$ and total dissolved salts were ranged from 225-665 $mg.l^{-1}$, and all water samples ranged from hard to very hard waters according to the total hardness values from 138-446 $mg.CaCO_3.l^{-1}$, while in all studied sites, cation were dominated by calcium followed by magnesium, then sodium and potassium in a descending order of concentrations. However anion concentrations were ranging from 24-544 $mg.l^{-1}$ recorded for sulfate, 50-660 $mg.l^{-1}$ for chloride, and from non detectable values of reactive phosphorus up to 1.14 µg at $P\text{-}PO_4^{-1}$. Furthermore, relatively high nitrate concentrations were found among all studied wells with concentrations ranging from 14-147 mg.l^{-1} that were unacceptable at sites 1, 5 and 8. Bacteriologically, about nintey-seven point 15 of the studied well water samples were suitable for drinking purposes, according to USEPA and WHO (2004) guideline.

Al-Naqishbandi et al., (2006) investigated the quality of water in Makhmur area. Duplicate samples of some natural water were taken, from twenty-one sites in Makhmur area along Debaga, Bakerta Makhmur center, and surrounding area during July and September 2006 to investigate the water quality, with regard to pollution as far as biological oxygen demand for five days incubation concerned the water found to be resonable in quality as BOD_5never exceeded 1.4 mg.l^{-1} whereas, in relation to nitrite the indignation of pollution where quite evident, however the value exceeded 28.46 in studied sites, as a whole the water very hard and often the hardness exceeded 3400 mg.$CaCO_3$.l^{-1}, alkalinity was generally low whereas, hydrogen ion concentration ranged from 7.0-8.8, in conclusion the area need continuous monitoring and more detailed investigations.

Limnological investigations in other parts of Iraq

A great number of investigations on the ground water quality were performed by many investigators in various places in other parts of Iraq.

Maulood et al., (1981), carried out a limnological and phycological studied on lowland Iraqi marshes. The physico-chemical variables were as follows; hydrogen ion potential ranged from 6.8-8.2, nitrate value ranged from 46-300 µg. as $N\text{-}NO_3$.l-^{1} and nitrite from 1.4-3.6 µg as. $N\text{-}NO_2$.l^{-1}. While alkalinity and reactive phosphorous values ranged from 5.4-29.6 meq.l^{-1} and 10-26 µg at P-PO4.l^{-1} respectively.

Depending on the salinity and total yield discharge and depth Iraqi's ground water classified into six districts. The first of which, include Duhok, Hawler, Sulaimaniyah, Mosul and part of Diyala, total yield of each well in these locations has a diameter of 6-10 inch, ranging between 150-1000 gallon per minute, with depth of about 10-50m and the total dissolved salt content is near 2000 ppm, while in certain places of the Kirkuk desert exceeds than 2000 ppm. Because of their importance for water supply and irrigation purposes the latter has been examined periodically during the last 40 years, but never on a seasonal basin. The analysis have been confined to the major ions in solution Sodium, Calcium, Potassium, Magnesium, Chloride and Bicarbonate, whereas the concentration of micronutrients had been neglected (Al-Sahaf et al., 1983).

Khorshid (1988) determined the levels of some important elements in drinking water of Baghdad city. Twelve districts on both sides of the Tigir's river were chosen. The physico-chemical parameters were as follow: total hardness values ranged from 122-540 mg $CaCO_3.l^{-1}$, sodium values ranged from 35-95 $mg.l^{-1}$, potassium value ranged from 1.4 -2.2$mg.l^{-1}$, chloride values ranged from 35-165 $mg.l^{-1}$, while heavy metals (Cd, Fe, Pb, Zn) ranged from 0.002 -0.061$mg.l^{-1}$, 0.040 -0.320$mg.l^{-1}$, 0.007 -0.058$mg.l^{-1}$, and 0.01-0.130$mg.l^{-1}$,respectively. Al-Jalil (2000) studied the impact of industrial water percolation on the pollution groundwater and surface water in Qaim, Iraq. Eight water wells were analyzed for a peroid of one year on monthly intervals and he found that the values of TDS, Chloride, Sulfate, Calcium, Sodium were high, whereas EC. and Phosphates were out of permissible limit. He concluded that there was a relative pollution with nitrate, sulfate, and calcium.

Conclusion

A great number of liminological studies have been conducted on various water systems within the Kurdistan region.Generally, the physico-chemical parameters were as follow; pH ranged 6.5-8, TDS ranged from , EC ranged from 0.37-2050 , DO ranged from 0.0-12.8 mgl^{-1}, Nitrate 16-230 $N.NO_3\ l^{-1}$, Nitrite up to 1.4 $N\text{-}NO_2.l^{-1}$, chloride 0.02-0.06 $meql^{-1}$, hardness 3.64-286 $mgCaCO_3.l\text{-}^1$, reactive phosphate 0.28-12.7 $P\text{-}PO4.1^{-1}$, respectively. Also, in the rest of Iraq, the physico-chemical variables were as follow; pH ranged from 6.8-8.2, TDS ranged from 122-540 mgl^{-1} , Na, 35-95 mgl^{-1}, K ranged from 1.4-2.2 mgl^{-1}, chloride ranged from 35-165 mgl^{-1}nitrate value 46-300 as $N.NO_3\ l^{-1}$ and nitrite from 1.4-3.6 $N\text{-}NO_2.l^{-1}$, alkalinity and reactive phosphours value ranged 5.4-29.6 $meq.l^{-1}$ and 10-26 $P\text{-}PO4.1^{-1}$, respectively. Also heavy metals such as Cd, Fe, pb, and Zn were ranged 0.007-0.058, 0.01-0.130, 0.002-0.061, and 0.040-0.320 mgl^{-1}, respectively.

All in all, according to Water Quality Index (WQI), most of the water sources requires primary treatment before use for drinking, whereas waters of Tanjaro river and Qiliasan stream cannot be used for drinking till they are treated (primary to tertiary treatments).

Refrences

[1] Abul-Rida, K.A. (1981). A bacteriological study on some well-waters used as drinking water sources. M.Sc. Thesis, Univ. of Baghdad, Iraq.

[2] Al-Bayathi, F.M.; Karim, S.A.; and Amir, Y.R. (1994). Evaluation of well-water quality assessment of Wadi-Lilan basin. Iraqi Sientific Society for water Resources. Jou. of Water Resources. 13(2):1-8.

[3] Al-Jalil, H.S.M.(2000). The impact of industrial waste water of a chemical phosphate company on the pollution of ground and surface water sources in Al-Qaeim. M.Sc. Thesis, Univ. of Baghdad, Iraq.

[4] Allenby, G and Margaret, M. (1993). World, Environment and People. Science Press, NSW, Australia.

[5] AL-Naqishbandi, L.M.; Toma, J.J.; Maulood, B.K.; and Ganjo, D.G. (2006). Astudy in quality in Makhmur, Kurdistan, Iraq.

[6] AL-Sahaf,M.,Al-Khasab, W.H.andAl-Ghitaa,B.A.(1983). Hydrology.Univ.of Mosul press. Mousl.Iraq. p. 389

[7] Al-Shahwani, S.M.H. (1980). A study on the primary productivity of Sarchnar spring.M.Sc.Thesis,Uni.of .Sulaimani.

[8] Ambient (2001). Water Module: Guide to Water. Accessed 21/11/01, http://www.rsmas.miami.edu/groups/niehs/ambient/teacher/water/Twater1.htm1.

[9] Anon, (1975). UNDP Tech. Rep. Contribution on natural resources Research Iraq.Inst.Appl.Res.Nat.Res.,Abughraib,Bagdad.

[10] Antoine, S.E. (1977). Seasonal variation of environmental characteristics and phytoplankton blooms of the river Tigirs Iraq. M.Sc Thesis, Univ. Basrah, Iraq.

[11] Australian Bureau of Meteorology. (1991). The Atmosphere of the Living Planet, Earth. Published by Bureau of Meteorology, Australia.

[12] Australian Bureau of Meteorology. (1993). Weather Eye on Australia, Reprinted from Australian Geographic Issue, No. 30, April-June, 1993. Published by Bureau of Meteorology, Australia.

[13] Aziz, F.H. and Ganjo, D.G.A. (2003). Nutrient status and algal flora in the Halgurd (Hasarost) mountain area within Arbil province, Iraq. Zanco sci. J. Of Dohuk Univ.

[14] Bapper, U.H.K. (2004). Ecological study on the distribution of alage in different aquatic habitats within Erbil province. Ph. D.Thesis. Univ. of Salahaddin. Arbil.

[15] Barid, C., and Cann, M(2005); Environmental chemistry. 3 rd Edition, pp425.W.H Freeman and Company press, USA.

[16] Beckett, M. J. (1993). Land Contamination, Contaminated Land, Problems and Solution. Edited by Tom Cairney. Published by Chapman and Hall.

[17] Berka, C., McCallum., D and Wernick, B. (1995). Resource Mangement and Environmental Studies. Department of Civil Engineering, University of Columbia, Vancouver, Bc, Canada. Paper presented at: Lower Fraser Basin in transition: Symposium

and Workshop, Kwantlen College, Surrey, BC, Canada. <http:/www.ire.ubc.ca/ecoresearch/publica3.htm>.

[18] Bilbas, A.H.A. (2004). Phycolimnological study on some springs within Arbil province.M.Sc. Thesis. Higher education Coll., Univ. of Salahaddin-Hawler, Iraq.

[19] Blight, E. G. (1995). On Isolating a Landfill from the Surrounding Water regime. Microbiology of Landfill Sites, Eric Senor, 2nd ed, Published by CRC Press.

[20] Bouwer, H. (1978). In Groundwater Hydrology. Published by McGRA W-Hill, New York.

[21] Boyd, C.E., 2000: Water Quality. An Introduction. Kluwer Acad. Publisher, USA, P.330.

[22] Brock, T.D. (1979). In Biology of Microorganisms, Published by Prentice-Hall, Eaglewood Cliff, New Jersey.

[23] Brutland, H.G. (2001). World Water Day Thursday 22 March. Help Make the difference. http://www.worldwaterday.org.

[24] Chen, K., Lin C., QI, Zen N., Zhen G., Yijun X., Yiejie L and Zhuan S. (1991). The epidemiology of diarrheal disease in Suoth Eastren China. J. Diarrhoeal Dis Res Vol. 9:pp 94-99.

[25] Chnaray, M.A.K. (2003). Hydrology and hydrochemistry of Kapran basin Arbil north of Iraq.Ph.D. Thesis, Univ. of Baghdad, Iraq.

[26] Clark, F.E., Paul, E.A. (1989). In Soil Microbiology and Biochemistry. Published by Academy Press, San Deigo.

[27] DLWC:Department of Land and Water Concervation, (1995). Upper North Coast Groundwater Resource Study, NSW, Canberra.

[28] Dohuki, M.S.S. (1997). Evaluation of some wells and springs water in Dohuk governorate for irrigation and drinking purpose. M.Sc. Thesis, Education Coll.Univ. of Salahaddin Hawler,Iraq.

[29] EL-Yosif, F.Y. and AL-Najim, M.A. (1977). Surchinar spring, Hydrological and water quality studies. Zanco. 3(2): 195-213.

[30] Esmail, A.O. (1986). Limitation of some ground water suitability in Arbil plain for different uses. M.Sc. Thesis, Univ. of Salahaddin.

[31] Eyre, D. (1993) Water: The Science. Water In Australia. Edited by Michael Johnson and Stephen Rix. Published by Pluto Press Australia in association with the Public Sector Research Centre, University of New South Wales, Australia.

[32] Ganjo, D.G.A (1997). Limnological study on Ruwandiz river path within Arbil province,Iraq. Ph.D. Thesis. Univ. of Salahaddin, Arbil.

[33] Ganjo,D.A.G. and Toma, J.J. (2004). Daily variation in chemical stratification and algal population throughout vertical profiles of Dokan Lake.Kurdistan region, Iraq. I-Chemical stratification trends. National Jour.Chemistry. 14:212-223.

[34] Geldreich, E. E. (1996). Microbial Quality of Water Supply in Distrbution System. Publisher CRC Press Inc, 2000 Co-operate NW Boca, Roton, Florida 33-41.

[35] Gray, N. F. (1994). Drinking Water Quality, Problems and Solution. Published by John Wiely and Son, Baffins Lane, Chichester, England.

[36] Haddad, R.H.; Smoor, P.B.;Basho, D.Y.; Sarbaro, S.K.; AL-Azawi, A.L.; and AL-Damerchi, M.S. (1974). Ground-water resources of Arbil area. IARNR Tech. Bull. No. 70. Bagdad.

[37] Hameed, A.H.(1978). Studies on the ecology of phytoplankton of Shatt Al-Arab river at Basrah, Iraq. M. Sc. Thesis, Univ. of Basrah.

[38] Hammer, M.J. (1996). Water and Wastewater Technology, 3rd Edition, Published by Prentice-Hall Inc, Englewood Cliff, New Jersey.

[39] Hassan, I.O. (1998). Urban Hydrology of Erbil city region. Ph.D. Thesis, Univ. of Baghdad, Iraq.

[40] Health Stream. (2000). Health Stream Program 1 Newsletter- Issue 18. <http://www.water quality.crc.org.au/hs/HS18WEB.HTM>

[41] Howell, D., Alexander, J., Eyre, D. (1993). Water The Science. Water in Australia. Manging Economic, Environmental and Community Reform. Edited by Micheal Jason and Stephen Rix. Public Research Centre. Australia. http:// www.sciencedirect.com/science.

[42] Hueb, J.A. (2001). Improving Water, Planning and Management Worldwise. New World Water. Publication of World Water Council, France.

[43] Ibrahim, A.M.K. (1981). A study on the algal ecology of springs in Sulaimani province.M.Sc.Univ.of Sulaimani.

[44] Islam,A.A.K.M. and Hameed, H.A. (1985). Check list of Algae with a note on the limnlogical and oceanographic studies in Iraq. (1942-1982). Asiatic Society of Bagdad, Ahak -2, Bangladesh p. 63.

[45] Jennings, D.; Paul, S. and Diane, D.W. (1997).Nitrates in Drinking water. Washington State Department of Health (WSDOH). An electronic media retrieved from the website: http:// www.doh.wa.gov/ehp/dw.

[46] Kamess.H.S. (1979). An ecology study on water pollution in Tangaro valley M.Sc.Thesis.Univ.of Sulaimani. (In Arabic).

[47] Khorshid, M.S. (1981). A study on water and soil pollution in Sulaimani region. M.Sc. Thesis. Univ. of Sulaimanyah.

[48] Khorshid, M.S. (1988). A study on diurnal variation of some physical and chemical characteristic of Sulaimani well water. Biological Science Research Jour.19 (Supplement): 935-947.

[49] Khorshid, M.S. (1988). Levels of some important elements in drinking water of Baghdad city. Biological Science Research Jour. Vol.19 (Supplement):924-934.

[50] Kolbe,R.W. and Krieger,W.(1942). Sussasseralgen aus Mesopotamian and Kurdistan. Berichted. Deut. Bot. Gesel.60:33-55.

[51] Lean, G., Hinrichsen, D., and Markham, A., (1990). Atlas of the Environment. Hutchinson, London.

[52] Lee, F.G., and Anne, J.L. (1993). Public Health Significance of Waterborne Pathogens in Domestic Water Supplies and Reclaimed Water.
http://water.sesep.drexel.edu/outbreaks/misc-documents/fredlee.htm.

[53] Mackenzie, W.R., Hoxie, N.J., Proctor, M.E., Gradus, M.S., Blair, K.a., Petersom, D.e., Kazmeirezak, J.J., Addies, D.G., Fox, KR., Rose, J.B., and Davis, J.P. (1994). A massive outbreak in Milwaukee of cryptosporidium infection transmitted through public water supply. New Eng. J. Med. Vol.331. No. 3:161-167.

[54] Maulood, B.K. and Hinton, G.C.F. (1979). Tychoplanktonic diatoms from a stenothermal spring in Iraq Kurdistan.Br.Phycol.J.14:175-183.

[55] Maulood, B.K., Hinton, G.C.F., Al-Saadi,H.A., Whittion,B.A and Hameed.H.H.(1981). On the algal ecology of the marshes of lowland. Mesopotamia.80:269-276.

[56] Maulood, B.K.and Hinton, G.C.F. (1978).Observation on the algal flora of Sulaimani area(1)green and blue algae Zanco.Seeies A.4(1):55-75.

[57] Merit, W., and Press, D. (1997). Water Quality and Pig Performance. Facts sheet; Ministry of Agriculture, Food and Rural Affairs, On tario.
<ysiwyg://78http://www.gov.on,ca/OMAFRA/English /livestock/swine/facts/91-0711.htm>.

[58] Michiels, W.C., and Moyson, D.L.E. (2000). Bacteriological Analysis. Handbook of Water Analysis; edited by Leo M.L.Nollet. Published by Marcel Dekker Inc.

[59] Moe, C.L, Sobsey, M.D, Samsa, G.P, and Melsolo, V. (1991). Indicators of risk of diarrhoeal disease form drinking water in Philippine. Bull World Health Organ Vol. 69:pp.305-317.

[60] Moss, M. (2003). Changes in biologically active ultraviolet radiation reaching the Earth's Surface. Journal of the Royal Society of Chemistry.2, 5-15.

[61] Muhammad, S.A.M. (2004). An ecological study on the Aquatic life of Sarchnar spring, Chaq-chaq and Kiliassan streams, Sulaimani, Kurdistan region of Iraq. M.Sc. Thesis, Univ. of Sulaimani.

[62] Nabi, A.Q. (2005). Limnological and bacteriological studies on some well water within Hawler city, Kurdistan region, Iraq. M.Sc. Thesis. University of Salahaddin-Erbil, Iraq.

[63] Nathanson, A.J. (1997). Basic Environmental Technology, Water Supply, Waste Management and Pollution Control. 2nd (eds) Published by Prentice-Hall Inc.

[64] Ndege, G. (2001). Developing cleaner water. New world water. Publication of World Water Council, France.

[65] NDOH:National Department of Health. (2000). National Health Plan 2001-2010. Vol.3. Part1. Published by Department of Health, Port Moresby, Papua New Guinea.

[66] Payment, P., Siematycki, J., Richardson, L., Renaud, G., Franco, E, Pervost, M. (1997). A Prospective Epidemiological Study of gastro-intestinal Health Effects due to the consumption of Drinking Water.Int. J.Envirson Hlth Res Vol. 7:pp.5-31.

[67] Puckett, L.J. and Timothy, K.C. (2001). Transport and Fate of Nitrate in a Glacial Outwash Aquifer in Relation to Ground Water Age, Land Use Practices, and Redox Processes. United States Geological Survey USGS. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. Journal of Environmental Quality 31:782-796.

[68] Putnam, S.W., and Wiener J.B (1995). Seeking safe drinking Water in Graham J.D and Wiener J. B (eds) 1995, Risk versus Risk-Trade off in Protecting Health and Environment. Harvard University Press, Cambridge and London, pp. 124-148.

[69] Rasheed, R.O. (1994). A limnological study on the some water system in Arbil province.M.Sc. Thesis, Univ. of Salahaddin.

[70] Readdy, K.J. and Lin, J.M. (1999). Nitrate removal from groundwater using catalytic reduction. Science direct research .Vol. 34, 3(14).

[71] Reinhold, V.N. (1992). Ground water Treatment Technology, 2nd Ed. Evan K Nyer.

[72] Roefer, P.A., Monscvitz, J.T., and Rexing, D.J. (1996). The Las Vegas cryptosporidiosis outbreak.J.AWWA: Vol. 88: pp.95-106.

[73] Rosen, M.R.; Reeves, R.R.; Green, S.; Clothier, B. and Ironside, N. (2004). Prediction of Ground water nitrate contamination after closure of an unlined sheep feedlot. Vadose Zone Journal.Vol.3(6) 990-1006.

[74] Shekha, Y.A. (2001). An Ecological study and Bacteriological study for ground water in Arbil region. Jour. Of Brayati center. 18:207-221.

[75] SIA: Bullrtin No 86. (2000). Guidance on the Use of Rainwater Tanks – The Facts. Published by Stormwater Industry Association Inc, Australia.

[76] Stevens, M., McCounell, S., Nadehaum, P., Chapman, M., Ananthakumar, S., McNeil, J. (1995). Drinking Water Quality and Treatment Requirements: A Risk-based Approach. Water, December 12-16.

[77] Tomar, M. (1999). Quality Assessment of Water. Published CRC Press.

[78] UN:United Nation. (1997). Comprehensive Assessment of the Freshwater Resources of the. World Meteorology Organization, Geneva, Switzerland.

[79] UNEPA/WHO:United Nation Environmental Program Agency/ World Health Organization. (1996). A practical Guide to the Design and Implementation of fresh water quality studies and monitoring. Edited by Jamie Bartram and Richard Balance. Publish on behalf of UNEPA/WHO, 1996.

[80] UNEP: United Nation Environment Program, (1996). Characterization and Assessment of Groundwater Quality Concerns in Asia-Pacific Region. Environmental Assessment Report, Prepared by British Geological Survey. UNEP/DEIA/AR.961.

[81] USEPA: Edition of the Drinking Water Standards and Health Advisories. Office of water United States Environmental Protection Agency (2004). Washington,DC.

[82] USEPA: United States Environmental Protection Agency (1993). Preventing Waterborne Disease: A focus on EPA's Research. Office of Research and Development, Washington, April 1993.

[83] Viste, A.D., Rice, A.J. (1994). Major sources of groundwater contamination; Assessing the extend of point and Non-point Contamination in Shallow. Aquifer System. Groundwater Contamination and Control. Edited by Uri Zoller.

[84] Weinstein, M.S. (1980). Health in the city, Environmental and Behavioral Influences.

[85] WHO and MOH: Quality Control of Drinking Water from Pollution, Technical Report. Northern Iraq.Office of World Health Organization WHO., and Ministry of Health MOH.(1998), Erbil Governorate, Northern Iraq.
[86] WHO:World Health Organization, (1993). Guidelines for Drinking Water Quality, 2nd (eds), Vol.1. Recommendations. World Health; Geneva. p. 445.
[87] WHO:World Health Organization, (1997). Guidelines for drinking water quality. 2nd (eds), Vol. 3. Surveillance and control of community supplies. World Health Organization; Geneva. p.520.