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Natural and drinking water quality in Erbil, Kurdistan

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ABSTRACT

This review evaluates and summarizes results of short term or long term projects monitoring published papers concerning water quality in Erbil governorate. Number of studies was conducted on monitoring the physical, chemical and biological quality of natural and drinking water in Erbil. The quality of water samples were generally fluctuated from safe to unsafe for drinking due to the variation of the studied properties with time and sample sites. The results indicated that investigated waters were fresh well aerated with dissolved oxygen, rich in sodium, sulphate and calcium in some sites. While other sites showed an evident case of pollution. Bacteriological examinations showed that greater zab river water was not safe for drinking due to the presence of bacterial indicators. The representative data of nutrient status suggested eutrophic conditions of lake water with alkaliphilous and hard water characteristics.

Key words: Drinking Water, Ground Water, Water Quality, Water Quality Guidelines.

INTRODUCTION

The sources of drinking water (both tap and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over surface of the band or through the ground, it dissolves naturally-occurring minerals and in some cases radioactive materials and pick up substances resulting from the presence of animals or from human activity[1]. Contaminants that may present in source water include viruses and bacteria, which may come from sewage treatment plant, septic system, agriculture livestock operations and wild life, inorganic contaminants such as salts and metals, organic chemicals such as pesticides and herbicides, contaminants from industrial process and petroleum use; and radioactive contaminants. The united state has one of the safest water supplies in the world[2]. However national statistics don't tell customers specifically about the quality and safety of the water coming out of their tap, that's because drinking water quality varies from place to place, depending on condition of the source of the water from which it's drown and the treatment it receives.

Water quality

Water quality is water that is safe for human to drink and to use for other domestic purposes, such as cooking, washing up, bathing and showering[3]. Ideally drinking water should be clear, colorless, and well aerated, with no unpalatable taste or odour, and it should contain no suspended matter, harmful chemicals or pathogenic micro organisms. In other words drinking water is safe to drink over a lifetime; that is, it constitutes no significant risk to health.

Water quality is the physical, chemical and biological characteristics of water[4]. The primary bases for such characterization are parameters which related to drinking water safety of human contact and for health of ecosystem. The vast majority of surface water on the planet neither potable nor toxic. This remains true even if sea water in the oceans (which is too salty to drink) isn't counted. In fact water quality is a very complex subject, in part because water is a complex medium intrinsically tied to the ecology of the earth. It has been shown that 1.1 billion people around the world have no access to safe drinking water[5], expected growth of the global population by another 2 billion people within next 25 years needing more drinking water and sanitation.

Water contamination is now a serious and a complex problem as you are reading this article, population and industry are continuing to make greater demands on our water resource, with which demand the problem escalates[6]. Life, liberty and pursuit of happiness should not have to take a back seat while we search for clean water in our daily lives. The simplest first line of defense is to use only water you are reasonably certain is potable.

Water quality mesurements

The complexity of as a subject reflected in many types of measurements of water and waste water quality indicator. These measurements include (from simple and basic to more complex):[4] physical and aggregate properties color, turbidity, odor, taste, pH, total hardness(TH),oxygen demand(OD), electrical conductivity(EC), salinity, total dissolved solids(TDS), total suspended solid(TSS), and temperature. It was found that, EC of water well correlated to its current alkalinity, with the presence of carbonate bed rock under natural conditions, and thus serves as an index of bedrock type[7].

Metals the natural analysis for physical and chemical properties including trace element contents are very important for public health studies[8].

Inorganic non metallic Constituent Nitrogen (NH_3, NO_3^-, NO_2^-..), Sulpher SO_4^{-2} SO_3^{-2},S^{-2}), Chlorine (Cl^-, ClO_2,……) and Several other carcinogens or toxic contaminants also appeared in water supplies including arsenic from industrial processes or natural process. A new flow injection chemiluminescences system developed for determination of sulfate and nitrate water in deferent regions in Erbil city[9].

Aggregate Organic Constituents includes chemical Oxygen demand (COD), Biological Oxygen demand (BOD), disinfection by products, Surfactant, pesticides and herbicides. Pesticide contamination of surface and ground waters has been well documented worldwide and constitute a major issue that gives rise to concerns at local, regional, national and global scales[10-11], as well as industrial and commercial facilities and transporters responsible for oil or other toxic spills[12].

Radioactive Elements high value of radioactive elements (for example more than 9µgL-^{1} U) present in drinking water may lead to harmful biological effects in human. The chemical toxicity of natural uranium is a major hazard to the kidney[13]. The estimation of U in water serves two purposes; it may lead to the hydro geochemical prospection of U and an assessment of the health risk[14]. No study was found on the estimation or detection of radioactive elements in water in Erbil province.

Microbiological characteristics In water supplies, the pathogens of concern are mainly those found in the faeces of human or animals. Pathogens of human are generally regarded as the greatest health risks from water supplies, as many of the significant water born diseases such as cholera and typhoid are found only in human. Currently, no detailed investigations on the characteristics of water including Guardia have ever been undertaken in quality control laboratories in Erbil province. It was shown that as a result of disposal of human wastes into the sources of water, natural water becomes highly polluted with faecal coliform[15].

Objectives

The objectives of this review are to summarize the existing informations about the natural and drinking water quality from the results of short term and long term research projects monitoring published papers concerning drinking water quality in Erbil governorate. Also to identify the existing technologies and to describe missing information needed to make assessments of predictions.

Water quality and public health

The importance of good drinking water in maintaining human health was recognized long ago[3], water storage and treatment are mentioned in historical records dating back nearly 3,000 years. By the early 1900s, rate of water born diseases were greatly reduce in developed nations by better protection of water supplied from sewage pollution. The wide spread introduction of disinfectants in the early twentieth century improved public health even further. However water born diseases continue to be major cause of illness and death in many less developed nations, 80% of all diseases and 25% of all death in developing countries can be attributed to polluted water(WHO)[5].According to the statistical informations provided by the health directory in Erbil province, the total number of death in 2006 and 2007

Table 1: Some physical statuse of water samples from the studied sites

S. No	Type	T. Turbidity NTU	DO mgL^{-1}	TDS mgL^{-1}	T C°	Ref
1	Spring	2.56	7.27	93.33	10.7	47
2	Spring	87.8	0.49	1452.22	15.1	
3	Spring	58.7	0.08	1445	14.4	
4	Spring	71.1	0.03	1442.22	14.7	
5	Spring	3.53	1.97	201.11	13.3	
6	Spring	7.23	3.03	237.78	21.4	
7	Spring	11.4	6.02	248.89	19.4	
8	Spring	6.67	4.59	260	19.5	
9	Spring	5.92	2.34	636.67	15.8	
10	Spring	4.29	5.52	284.44	14.8	
11	Spring	5.6	7.7	308.89	16	
12	Spring	5.87	5.79	788.89	16.6	
13	Spring	11.1	5.79	688.89	15.7	
14	Spring	34.3	2.47	334.44	14.6	
15	Spring	5.32	4.01	303.33	17.8	
16	Spring	4.19	6.61	426.67	16.1	
17	Spring	4.06	6.89	243.78	17.6	
18	Spring	7.44	10.08	633.33	15.7	
19	Spring	18.3	7.07	425.56	17.9	
20	Spring	17.3	5.87	309.22	18.3	
21	River	10.9	6.1	211.5	33	
22	River	17.7	5.9	252.5		
23	Well	1		420	27	
24	Well	0		400		
25	Well	0		400		
26	Well	0		400		
27	Well	0		400		
28	Well	1		400		
29	Well	0		410		
30	Well	0		380		
31	Well	1		330		
32	Well	0		300		
33	Well	0		300		
34	Well	1		300		
35	Well	0		310		
36	Well	0		330		
37	Well	1		310		

were 3020 and 2881 respectively. So the number of death due to polluted water in 2006 and 2007 were 755 and 720.25 respectively.

The study on the major Environment related killers in children under five years showed that diarrhea kills an estimated 1.6 million children each year caused mainly by unsafe water and poor sanitation. In many cases, low cost solutions for environment and health problems exist. For instance simple filtration and disinfection of water at the household level dramatically improves the microbial

Table 2: Some chemical statuse of water samples from the studied sites

S. No.	Type	PH	EC μscm^{-1}	COD mgL^{-1}	BOD mgL^{-1}	T. Alkalinity mg $CaCO_3L^{-1}$	T. Hardness mg $CaCO_3L^{-1}$	Cl^- MgL^{-1}	Ref.
1	Spring	7.37	190		1.52	113.2	83.33	5.942	47
2	Spring	6.68	2906		10.49	1763	593.9	17.76	
3	Spring	6.64	2909		11.33	1568	540	17.72	
4	Spring	6.61	2884		11.47	1598	508.9	16.59	
5	Spring	7.38	403.3		0.72	250.7	129.3	11.25	
6	Spring	7.63	467.8		0.82	265.3	147.2	13.93	
7	Spring	7.41	503.3		1.09	250.9	133.2	9.558	
8	Spring	7.34	522.2		1.07	258.7	144.7	8.946	
9	Spring	7.4	1258		2.03	346.3	164.4	76.43	
10	Spring	7.35	572.2		1.45	287.8	142.3	18.15	
11	Spring	7.54	618.9		2.23	266.3	138.6	11.78	
12	Spring	7.32	1578		1.96	228.3	142.3	24.89	
13	Spring	7.52	1381		2.21	239.9	127.2	19.28	
14	Spring	8.2	672.2		1.88	344	42.44	10.34	
15	Spring	7.39	607.8		0.95	288.4	143.4	14.88	
16	Spring	7.51	851.1		1.27	338.9	156	31.34	
17	Spring	7.53	493.3		2.33	208.1	138.1	18.46	
18	Spring	7.87	1268		3.2	431.7	185.6	60.72	
19	Spring	7.39	847.8		1.71	332.3	151.2	40.22	
20	Spring	7.35	606.7		1.48	294.1	141.9	16.25	
21	River	7.9	423.6			160.5	176.3		33
22	River	7.8	504.5			161.6	169.3		
23	Well	7.3	840		1	280	360	16	27
24	Well	7.2	810		1	260	340	18	
25	Well	7.1	800		0.9	264	340	14	
26	Well	7.3	810		0.8	220	320	15	
27	Well	7.3	810		1	256	344	12	
28	Well	7.2	800		0.9	260	350	16	
29	Well	7.4	820		1	230	370	14	
30	Well	7.4	760		0.9	250	310	12	
31	Well	7.5	660		1	210	320	12	
32	Well	7.4	610		1	220	300	15	
33	Well	7.3	610		0.9	210	290	14	
34	Well	7.4	610		1	220	260	14	
35	Well	7.6	620		0.8	200	280	16	
36	Well	7.4	660		0.7	220	288	14	
37	Well	7.3	620		0.7	210	290	18	

quality of water and reduces the risk of diarrhreal disease of low cost (WHO)[13].

Description of the studied area

Erbil province is the capital of Iraqi Kurdistan with about one million populations and situated in the northeast of Iraq. Its boundaries extended from longitude 43° 15¯E to 45° 14¯E and from latitude 35° 27¯N to 37° 24¯N. [16] .The climate most closely to Irano–Turanian type .The annual rain fall may exceed 1000 mm. The average rain fall in Erbil city is 440 mm. Erbil city is currently served by two types of water resources[17-18].

Table 3: Nutrient statuse of water samples from the studied sites

S. No.	Type Location	SO_4 mgL^{-1}	SiO_2 mgL^{-1}	NO_2 mgL^{-1}	NO_3 mgL^{-1}	NH_3 mgL^{-1}	PO_4 mgL^{-1}	H_2S mgL^{-1}	CO_2 mgL^{-1}	Ref.
1.	Spring	66.22	169.6	0.065	58.76	0.85	0.767	0.626	2.272	47
2.	Spring	94.67	429.1	0.074	117.5	1.178	1.741	4.544	23.45	
3.	Spring	103.1	431.5	0.095	104.5	1.102	2.099	4.304	23.12	
4.	Spring	105.8	464.2	0.127	118.5	1.241	1.558	3.789	23.67	
5.	Spring	68	192.6	0.064	64.28	0.889	0.649	1.66	3.711	
6.	Spring	142	177.5	0.077	78.35	0.836	0.869	1.478	3.439	
7.	Spring	84.44	161.5	0.07	59.76	0.856	1.132	1.358	3.461	
8.	Spring	62.44	168.9	0.047	59.26	0.814	0.932	1.877	3.039	
9.	Spring	327.3	313.6	0.058	68.8	0.893	1.116	3.902	9.3	
10.	Spring	118.1	223.4	0.175	66.6	0.879	0.841	1.26	6.367	
11.	Spring	94.44	157.8	0.08	66.8	0.906	0.328	1.36	5.539	
12.	Spring	177.3	170.8	0.151	69.35	1.049	1.032	1.316	4.744	
13.	Spring	123.6	212.5	0.075	121.5	1.016	1.178	1.82	5.022	
14.	Spring	98.67	310.2	0.224	64.28	1.269	0.761	1.526	6.85	
15.	Spring	103.8	125.4	0.059	114.5	0.884	1.232	1.663	5.517	
16.	Spring	225.4	250.9	0.243	66.8	0.914	1.284	1.224	5.5	
17.	Spring	11.6	127.2	0.047	101.4	0.914	1.743	1.499	4.583	
18.	Spring	260.9	338.9	0.075	76.34	1.091	1.425	2.182	8.167	
19.	Spring	200.9	321.5	0.069	70.81	1.034	0.963	1.861	6.2	
20.	Spring	160.4	218.1	0.132	6579	0.952	1.897	1.678	5.328	
21.	River	35.1		0.006	6.3					33
22.	River	31.3		0.005	5.2					
23.	Well	176	40.5	0.07	1.5		0.05			27
24.	Well	154	34.5	0.2	1.2		0.25			
25.	Well	175	40.9	0.1	2.4		0.35			
26.	Well	157	38.4	0.2	2		0.5			
27.	Well	166	31.5	0.07	2.5		0.25			
28.	Well	186	35.5	0.07	2.3		0.2			
29.	Well	161	28	0.1	3		0.15			
30.	Well	153	22.5	0.22	2.8		0.2			
31.	Well	144	22.2	0.12	1.8		0.1			
32.	Well	136	21.4	0.07	0.7		0.15			
33.	Well	112	27.8	0.15	0.8		0.15			
34.	Well	120	28.3	0.25	1		0.05			
35.	Well	124	30.7	0.15	0.3		0.5			
36.	Well	137	25.4	0.12	0.8		0.45			
37.	Well	136	30.2	0.17	0.6		0.55			

Ground water

There are about 500 deep wells in Erbil. Drinking water from these wells is continuously analyzed daily or twice a week in central quality control laboratory in Erbil Teaching Hospital.

Table 4: Metalic statuse of water samples from the studied sites

S. No.	Type	Ca mgL^{-1}	Mg mgL^{-1}	Na mgL^{-1}	K mgL^{-1}	Cu mgL^{-1}	Al mgL^{-1}	Fe mgL^{-1}	Ref. mgL^{-1}
1.	River	34.3	21.9	3.4	0.8	0.33	0.11	0.005	33
2.	River	33	21.1	3.8	0.8	0.29	0.15	0.005	
3.	Well	104.3	24.3	3.2	0.5				27
4.	Well	96.3	24.3	3.8	0.4				
5.	Well	120.2	9.7	4	0.5				
6.	Well	104.1	14.5	3.5	0.5				
7.	Well	122.6	9.2	2.8	0.4				
8.	Well	92.1	29.1	3.6	0.5				
9.	Well	84.1	38.8	4.2	0.3				
10.	Well	88.1	21.8	5	0.2				
11.	Well	68.2	36.4	4	0.4				
12.	Well	88.1	20.4	3.5	0.6				
13.	Well	56.1	24.3	3	0.5				
14.	Well	52.1	31.6	3.2	0.4				
15.	Well	56.2	34	2.8	0.5				
16.	Well	68.2	28.6	2.6	0.6				
17.	Well	56.1	36.9	2.5	0.7				
18.	Kasn.Impo.	67.2	14.11	7.7	0.7				40
19.	Kasn.Impo.	30.08	15.66	9.2	1.3				
20.	Stream	66	26	8.2	2.1				37
21.	Stream	392	33	8.9	2.8				
22.	Spring	13.42	10.56						47
23.	Spring	155.6	47.97						
24.	Spring	147.9	44.47						
25.	Spring	131.4	44.7						
26.	Spring	34.11	10.66						
27.	Spring	37.22	8,967						
28.	Spring	37.56	8.813						
29.	Spring	37.87	7.491						
30.	Spring	42.33	14.92						
31.	Spring	35.8	12.35						
32.	Spring	36.58	11.28						
33.	Spring	43.27	7.293						
34.	Spring	33.11	10.37						
35.	Spring	8.578	5.707						
36.	Spring	32.67	14.16						
37.	Spring	37.87	14.66						
38.	Spring	32.98	14.17						
39.	Spring	41.07	19.36						
40.	Spring	33.3	16.2						
41.	Spring	30.31	15.37						

Surface water

The upper or grater Zab River together with Rawanduz river are the only source of surface water available for supplying water for drinking and other purposes. The grater zab originates in Turkish Kurdistan and is partly regulated by the Bekhma dam. Its length is 392 Km from the source to Almakhlut village in south of Mosul[19]. Three Water treatment plants (WTP) have been constructed with intake of raw water from this river at Efraz village;

Efraz 1 (conventional WTP) constructed in 1968 with design capacity of 38400 m³/day. This is an old WTP and most treatment units in this plant are in poor condition which requires repair and good maintenance.

Efraz 2 constructed in 1985 with a design capacity of 69000m³/day. Currently it supplies about 44000 m³/day.

Table 5: Seasonal changes in; (a) total number of species and individuals and (b) chlorophyta(mgm-3) of epilithic algea at two sites on mountainous stream during jan-dec 1998(ref.40)

Months	No. of species cm^{-2}		No. of individuals($\times 10^2 cm^{-2}$)	
	Downstream	Upstream	Downstream	Upstream
Jan	8	12	16	26
Feb	7	10	18	27
March	14	20	26	38
April	18	22	35	44
May	20	28	40	47
June	12	13	18	26
July	11	14	19	30
Aug	9	12	20	20
Sep	12	18	28	22
Oct	15	20	28	30
Nov	17	20	19	29
Dec	10	18	12	22

Table 5 (b):

Months	Upstream	Downstream
Jan.	8.1	10.2
Feb.	12.2	16.6
March	21.5	30.5
April	27.7	35.2
May	22.3	28.3
June	12.4	18.7
July	11.9	18.1
Aug.	13.8	18.9
Sep.	18.2	25.4
Oct.	22.7	28.4
Nov.	15	20.2
Dec.	8.8	12.6

Efraz 3 constructed in 2006 with a design capacity of 144000 m³/day. The treatment processes in these plants includes four main steps; screens, sedimentation (coagulation and flocculation) filtration and chlorination. Each plant is provided by a quality control lab for daily water analysis. Moreover, there are many other water resources in Erbil province like streams, springs, ponds, impoundments and Kahreez.

Water quaklity in erbel

Ground water quality in Erbil

Investigations of the quality of ground water have been continuously performed by many researchers in Erbil Province. Ari *et al* [20] studied ground water from fifteen wells within Erbil City at bimonthly interval periods from Sep 2004- April

2005. According to WHO and IS.EPA (2004) guidline values about 97.15% of the studied wells water were suitable for drinking and 87.15% showed no growth regarding to coliform-MPN. They observed relatively high nitrate concentration (14-147 mgL^{-1}), which was attributed to the contamination by sewage water that passes through the city. Similar conclusion was made by other researchers in Erbil[21-22] and in United State[23]. At the same time these authors observed that shallow wells revealed higher nitrate level than the deep wells. Similar observation was found in other areas within Erbil province[24]. In contrast, the distribution of nitrate concentration in the city of konya, Turkey is not correlated with well depths within the studied area[25]. In 2004[26] another study was conducted to monitor the quality variation through one year for water samples taken from a well in Erbil city center. The author concluded that there is no noticeable seasonal change in quality of water taken from the studied well. Fifteen wells in Shaqlawa have also been studied during Dec 2005-March 2006[27].Seventeen physico–chemical variables of drinking water quality were studied (Tables 1,2,3 and 4). It has been shown that almost all the studied wells water classified as clean water and is suitable for drinking purposes.

Finally Layla *et al*.,[18], studied the quality of water samples from 24 wells in different villages in Erbil during July–Sep 2006. Regarding the EC, TH and TDS all the studied wells (except one) were not considered potable. The concentrations of Na was found to be higher than that of K and much less than Ca, in most of the studied wells the amount of sulphate, chloride, nitrate and phosphate exceeded the maximum allowed concentrations. Faisal et al[28] conducted a Study on Erbil city ground water and data of physico–chemical and biological tests were collected and compared with the standards issued by international regulations interested in this field, according to Middle Asia classification the analyzed data showed that 91.6-100% of the studied wells were in good situation. Consequently, the studied ground water is suitable for drinking and domestic purposes they also obtained an empirical equation which shows the relation between TDS and EC for all studied wells. The study of the quality of water samples from twenty four wells in Makhmure showed a wide range of EC in the studied area which was related to the differences in climate, lithology and geological formation, the effect of input and out put as well as evaporation[18].

Surface water quality in Erbil

Many studies have been done in different land water systems including, Rivers, Lakes, Ponds and Springs in Erbil Province.

Rivers

Comprehensive phycolimnological studies was done[29-30] on algal abundance with their distribution and periodicities, succession and productivity along Rawanduze river path from Haji Omaran to Gali Ali Bag with other sites including springs, streams and one pond. They found that the PH of all the studied sites lies in the alkaline side of neutrality which is a well known phenomena for Kurdistan inland water, EC, TH, T. alkalinity, DO, BOD were all in the acceptable levels. Regarding the biological structure, a total of 1016 taxa adding 338 taxa to the Iraqi algal flora including 184 taxa of non diatoms and 154 taxa of diatoms.Layla *et al*.,[31] studied water of greater Zab during April–Nov. 2001 they found that the greater Zab river characterized as fresh, semi clear alkaline, moderately hard, with high sulphate, strong ionic strength, high nitrite concentrations, with high organic matter content and in un healthy situation with regard to bacteriological tests including MPN for faecal, total caliform *streptococcus faecalis* and *Escherichia coli*.

At 2002 Al-Naqishbandi[32] conducted a limnological study on the water treatment plant in Efraz on greater Zab within Erbil Region. It has been shown that, the water turbidity was higher than the acceptable level, alkalinity and sulphate were higher than the acceptable level. While the result in tables 1 and 2 showed that the studied wells were in acceptable level of total turbidity and a wide range of EC. Nutrient contents were between 17.4 -38.78 mg at N-NH3 L^{-1} 0.24-6.7 mg at N-NO_3 L^{-1}, 0.06-2.63 µg at N-NO2 L^{-1} and 0.08-0.78 µg at P-PO4 L^{-1}. It was also observed that the river considered unsafe in Bahdinan region due to the presence of feacal caliform bacteria.

Furthermore, the characteristics of greater Zab river was studied by other researchers during 2004 -2005[33-34], they explained the high turbidity of the river's water by inefficient treatment or resuspension of sediment and the surface run off that enters the river. Their results showed that Greater Zab River water can not be used for drinking directly. According to the United State Salinity guidelines this river is of type B and is acceptable for irrigation. It can be classified as good to excellent according to EC, TDS, SO_4, Cl ,Na and safe for fish. It can be considered unpolluted river according to BOD.

In another study[26] on the Greater Zab river water quality variation monitoring for one year interval (Aug 2003-Jul 2004) it has been shown that water of this river requires good treating in raining seasons, so it was recommended to construct a pre-sedimentation tank in Efraz Treatment Plant. Analysis of water samples from Greater Zab river conducted by other researchers demonstrated that greater zab water is considered as low Na content and safe for irrigation[19].Some empirical equations were obtained to show the relationship between TDS, TH, alkalinity, sodium adsorption rate with flow rate of that river.

Streams and Springs

Liminogical study was done on some water systems including springs, streams, impoundments and Kahreezes within Erbil Province by Rasheed [35], The Results showed that the PH lies in the alkaline side of neutrality, EC and TH were in the acceptable range while the DO exceeded the Saturated Level, and reactive phosphate was found to be limiting for growth of standing crop. The maximum number of phytoplankton counted in impoundments were considerably high and approach 10 cell L^{-1}, At 1995 Al Berzangy[36] identified 198 taxa mainly they were belonged to cyanophyta and chlorophyta with their seasonal variation and periodicity in different water systems including Springs , Streams , Kahreezes , lakes and small ponds within Erbil Province. The quality of water samples from many streams in Korre and Shaqlawa was studied during 1994–1996[37]. Twenty five morphological and physico–chemical variables related to water minerals and nutrient status were analyzed their results in tables 3&4 showed that both investigated water courses were fresh, rich in Na, SO4 and Ca and in eutrophic condition at Korre, and an evident case of pollution was observed at shaqllawa streams.

The water quality of many mountainous stream was monitor from Jan-Dec 1998[38].Their results showed that the studied water was slightly alkaline, hard and nutrient rich, Algal biomas was relatively high(Tables 5; a and b), the maximum total abundance and taxa richness of 2.6×10 cells cm^2 and 28 species were recorded during spring season chlorophyta productivity was mostly related to filamentous green algae with 8.1-35.2 mgm^{-3} during winter and spring Epilithon algal community was dominated by bacillariophyta during the studied period followed by cyanophyta then by cholorophyta. furthermore Aziz and Ganjo[39] recorded 210 algal taxa including 109 diatoms and 101 non diatoms in streams, springs, and small pond in the highest mountain in Iraq(Halgurd). Their results showed that the PH was slightly alkaline, EC, TH and alkalinity were in the acceptable levels. The concentration of DO was in the range of 4.1-5.4 mgL^{-1} nitrate, phosphate and silicate were in the range of 12.7–21.2mg at $N\text{-}NO_3L^{-1}$, 0.12–0.62µg at $P\text{-}PO_4L^{-}$ and 5.6–67.6µg at $Si\text{-}SiO_2\,L^{-1}$. Consequently, the studied waters were in eutrophic conditions.

Kasnazan Impoundment in Erbil

The quality of water from Kasnazan Impoundment in Erbil was studied by many researchers for drinking and irrigation purposes. Water samples were taken from Kasnazan Impoundment[40] weekly during Oct–Dec 2003. The results showed a fluctuating level of EC, alkaline PH range , Variation in alkalinity with high DO and it was considered as hard water. The distribution of cations shows the following order Ca>Mg>Na>K. Nitrate was dominate form of inorganic nitrogen. Phosphate and silicate showed no regular weekly variation. A total of 33 species of algae was recorded chlorophyte and chrysophyta were the dominant groups. Water quality of Kasnazan Impoundment was monitored in 8 samples locating during Sept 2005–Mar 2006 at bimonthly interval periods[41]. It has been shown that the values of the EC were fluctuated seasonally and the increase in water conductivity a companied by increasing the TDS. No significant differences were observed between the sampling sites regarding DO. They attributed the seasonal variations in DO concentration at studied period to dissolved salts, partial pressure of gasses, input organic matter, climate, light transparency and phytoplankton. The saturation status of DO

(7-9 mgL^{-1})was due to the large surface area of Kasnazan impoundment. The result of BOD throughout the investigation period exceeded the accepted level prescribed by WHO. While values of TH were in the accepted level. Thigh phosphate content of the studied samples was attributed to population density, type of cultivation, soil characteristics and pollutants. Seasonal variation in sulphate concentration was observed in studied sites which increased in autumn and decreased in winter. At the same time, these authors observed a low level of nitrate which was attributed to the effect of macro-microphyte which utilizes the inorganic nitrate. Akram *et al*.[34], monitored monthly the quality of water samples from Kasnazan Impoundment during Aug 2004 – Feb 2005. Statistical analysis indicated that there was a significant difference between kahreez (site 1) and other sites in TDS and HCO_3 values while there was no significant difference in K concentration between the locations or times. They classified water from Kasnazan Impoundment as harmful for irrigation because Mg / Ca ratio exceed 1.On the other hand the dominant cation was Na while the dominant anion was Cl.Contrary to what is reported in literature [42-44] on water samples from the same source in which Ca and HCO_3 were the dominant ions. According to Ayers et al. [45] water of these sites regarded within the desirable limits.

Taiwan EPE plans to revise the drinking water quality standards for TH and TDS in the near future. The new standards require a lower TH concentration (from currently 400 to 150 mgL^{-1} $CaCO_3$ and lowers TDS maximum admissible concentration from current guidelines of 600 to 250 mgL^{-1} due to the impact on drinking water taste caused by variation in TH of TDS concentrations[14]. So the results in tables 1 and 2 showed that most of the studied water samples were beyond the acceptable level of TH according to Taiwan new EPE standards.

CONCLUSIONS

In light of the findings of this review we concluded that, the evaluation of the well waters can be assessed as good quality and are suitable for drinking with relatively high levels of nitrates and TDS indicating possible contamination of ground water via non point source of contaminants. The Greater Zab river con not be used for drinking due to higher than acceptable levels of turbidity, and some other characteristics, but it is acceptable for irrigation. Regarding the other sources of surface water, some of the quality parameters were within the permissible levels as prescribed by WHO and / or other organizations, while others are beyond the levels.

Management and Strategies

To insure the safety of drinking water supplies to the community at large including infants and the aged who are more at risk. The following points are required:

1. A management strategy should be based on protection from the source to the point of use [46]. These protecting include source protection, water treatments, distribution system integrity, monitoring surveillance and public information.
2. Establishment of drinking water quality standards / Guidelines in Kurdistan.
3. Currently various institutions (Ministries of health, Agriculture, Environment and Industry as well as the Universities) involved in collecting water quality data without collaborate or share data with each other. Thus for easy access to water quality data required, it is necessary that a national data base on water quality be established in Kurdistan.
4. Protection of ground water (wells) and distribution system pipes by sewage and wastewater.
5. Enhance public awareness at levels about the issues of drinking water quality.
6 Establish Kurdistan Environmental Protection Agency (K.EPA) for monitoring urban and rural drinking water quality. The Safe Drinking Water Act (SDWA) requires that EPA shall not less often than every 6 years revises and possibly revise each national primary water quality regulation promulgated by the agency. Whether EPA decides to revise the regulation for a given contaminant will depend in part on its occurrence in public water supplies, that's we need to Establish an EPA which works honestly and continuously. One of the major environmental issues of concern

to policy makers is the increased vulnerability of ground water quality.

7 Finally a range of agencies can be involved in water supply systems such as; water resource, natural local governmental agricultural , health departments , management agencies , community based interest groups and organizations can all have a role in protecting water quality.

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