JJBS

Jordan Journal of Biological Sciences

Volume 6, Number 4, December .2013
ISSN 1995-6673
Pages 308 - 315

Bacteriological and Mycological Assessment for Water Quality of Duhok Reservoir, Iraq

Yahya A. Shekha[1], Hero M. Ismael[2] and Akhter A. Ahmed[2,*]

[1]*Environmental Science Department,*

[2]*Biology Department, College of Science- Salahaddin University- Erbil, Iraq.*

Received June 24, 2013 *Revised: August 6, 2013* *Accepted: August 21, 2013*

Abstract

Duhok dam reservoir is situated in Duhok city, Iraq. It is an artificial reservoir which supplies water for crops land and orchard around the canal throughout its path. The objective of this investigation is to assess physical, chemical and microbiological aspects of aquatic ecosystem in the lake. The water quality variables (water temperature, pH, EC, total dissolved nitrogen and phosphate, SO_2 , BOD_5 and microoganisms) were being measured seasonally during 2011. The results reported that high conductivity and sulphate concentrations were recorded during different seasons. Heterotrophic plate count and faecal colifom exceed Iraqi and WHO standards for drinking purposes. Statistically, no differences were found between studied sites for all variables. Microbiological isolates, counts, total occurrence and diversity index were more in sediment than in water samples. The occurrence of mycobiota was surveyed by three isolation methods 19 fungal species assigned to 14 genera were isolated. The most frequent species in order were: *Aspergillus* spp., *Penicillium* spp. and *Eurotium* spp. The occurrence of keratinophilic fungi was detected in the sediment by hair baiting method The most frequent genera isolated in this study were *Chrysosporium* spp. , *Trichophyton* spp. and *Microsporum* spp.

Keyword: Water Quality, Duhok Reservoir, Bacterial Count, Fungal isolation, Biodiversity.

1. Introduction

Water quality performs an important role in the health of human beings, animals, and plants. Surface water quality is an essential component of the natural environment and a matter of serious concern today (Liu *et al.,* 2011). Rivers and reservoirs play a major role in drinking water, agricultural use, fishery, and electricity production, so protection of water quality is a very important issue and it should be kept at acceptable levels (Venkatesharaju *et al*., 2010). The variation of water quality is the essential combination of both anthropogenic (such as urban, industrial, agricultural activities and the human exploitation of water sources) and natural contributions (such as precipitation rate, weathering processes and soil erosion) (Pejman *et al*., 2009). Deterioration of lake and river water quality is common in many aquatic systems and potential causes are usually various including point and non- point sources of pollution (Pisinaras *et al.,* 2007).

In a well- balanced aquatic ecosystem, the quality of water plays a critical role between, the organisms and environment which is also extremely important for the health of the ecosystem (Akbulut *et al.,* 2010). In water quality assessment the microbial community has special significance, especially in terms of protecting public health. Coliform bacteria, normally present in intestinal tract of humans and worm- blooded animals, can secondary be found on plants, in the soil and in waters. Although the occurrence of primarily non- pathogenic refers to the presence of disease- causing organisms, they reach natural waters mainly during rainfall, through runoff from agricultural and urban lands, as well as through drainage (Radojevic *et al.,* 2012). Total coliform (TC) is used as a parameter giving basic information on microbiological quality of surface waters (WHO, 2008). For more than a century the presence of coliform bacteria in drinking and recreational waters has been taken as an indication of fecal contamination, and thus of a health hazard. Total coliform and thermotolerant (fecal) coliform (FC) indicator tests are common public health tests of the safety of water and wastewater which might be contaminated with sewage or fecal material (APHA, 1998).

Historically, water has played a significant role in the transmission of human disease. Typhoid fever, cholera, infectious hepatitis, bacillary and amoebic dysenteries and many varieties of gastrointestinal diseases can all be transmitted by water (Rompre *et al*., 2002).

The qualitative and quantitative composition of fungi in water sediments depend on the origin and composition of waste water sediments, stabilization degree of their organic

* Corresponding author. e-mail: akhter_micro@uni-sci.org.

matter, hydration degree and structure. It was postulated that keratinophilic fungi may be utilized as microbiological indices for the transformations of organic matter of waste water sediments as well as of the degree of their deactivation from the sanitary standpoint (Ulfig and Korcz, 1991).

Duhok dam is a high earth fill dam with central clay core and gravel shell. The main aim of the dam was irrigation of the agricultural areas inside Duhok city and areas around it till Summel city through a tunnel, now the reservoir area of the dam is used for supplying Duhok city with water beside it became a touristic area (Mustafa and Noori, 2013). It is 60 m (197 ft) tall and can withhold 52,000,000 m3 (42,157 acre.ft) of water. The dam has a bell-mouth spillway with a maximum discharge of 81 m3/s (2,860 cu ft/s) (Wikipedia, 2008).

The main objectives of this study were to assess the microbial water quality by detecting the presence of coliforms and fungi, as well as to determine the spatial and temporal pattern in the community structure of biota richness and relations to some physico- chemical parameters, in order to know the water quality of Duhok dam and their suitability to using it for different purposes.

2. Materials and Methods

2.1. Study Area

Duhok dam reservoir was established in 1988 on Duhok rubar (River) forming an impoundment of surface area around 256 hectares, coming third in Iraqi Kurdistan region, northern part of Iraq (Figure 1) after Dokan and Derbandikan reservoirs. Duhok impoundment is located about 2 Km to the north of Duhok city center of latitude 36° 50' 49" and longitude 43° 00' 33". It is an artificial reservoir with maximum depth exceeding 60 meter having an area of 6.8 Km^2 (1.7 Km width, 4 Km length) (Al-Nakhabandi, 2002).

The reservoir is situated on a hilly plane surrounded from the south by a mountain Chai Spii, whereas from the north by a chain of Zahio mountain. Most parts of the area are formed from the slopes and steep mountains crossed by numerous valleys all of which generally direct the water flow of rain, and snow melts through different creeks and canals to the main Duhok rubar, because of the steep slopes toward the center of the reservoir. This reservoir (rubar Duhok canal) supplies water for crops land and orchard around the canal throughout its path (Al-Ganabi, 1985). The establishment of the reservoir extended the irrigation nowadays to about 4600 hectares on the west of Duhok town, extending to approach the main international road Zakho. The source of the water to the dam is mainly rain, snowmelt and the main tributaries Sundor and Gurmava that on their joining made up Duhok rubar.

The impoundment has almost a fan- like shape with an elongated part to the north west, where the forest vegetation and orchards have been permanently under the water, the west and east shores of the impoundment are arable lands, therefore, the use of the fertilizers and pesticides are common, whereas in Spring and Summer seasons views of cattle and sheep for grazing were common in the area. The outflow of the impoundment is through the spillway discharge.

Figure 1. Maps of: Duhok city, Iraq, Duhok Dam Lake and studied sites.

2.2. Sample Collection

Water samples were collected at surface (0- 20cm) from three sites, while sediment samples were collected from two sites at depth 1m near banks of the reservoir (sites 1 and 3) in four different seasons during 2011. All samples were kept in a 2L sterilized plastic bottles, and stored in insulated cooler containing ice and delivered on the same day to laboratory and all samples were kept at 4 °C until processing and analysis.

2.3. Analytical Methods

2.3.1. Physico- chemical analysis

Water quality parameters includes: water temperature was measured by using a thermometer (accurate to nearest 0.1 °C), pH using pH- meter (Philips, 4014, UK), electrical conductivity using (EC meter, Philips, 4025, UK). The BOD_5 by the Winkler azid method, Sulfate by titrimetric method (APHA, 1998). Total nitrogen wet mineralized by using potassium persulphate as described by (MacKareth *et al.*, 1978), persulphate digestion method was used for total dissolved phosphate as described by (Lind, 1979).

2.3.2. . Microbiological analysis

For the bacteriological analysis of water samples, Coliform test was performed by the most probable number (MPN) technique (Benson, 1998) and heterotrophic plate count (aerobic) by Pour Plate method (Sugita *et al*., 1993). Standard MPN technique was applied using glucose azide broth for isolation of fecal streptococci (APHA,1998)

Detection of *Salmonella* spp was done by the enrichment of water samples on Selenite F broth, followed by isolation of the typical organism on selective medium, Xylose Lysine Deoxycholate Agar (XLD). Detection of *Vibrio cholerae* was done by enriching the samples in 1% alkaline peptone water for 6 to 8 hours followed by isolation on Thiosulphate Citrate Bile salt sucrose (TCBS) agar medium (Collee *et al*., 1996). For *Pseudomonas aeruginosa* both MacConkey agar , Nutrient agar were used as presumptive cultures and Mannitol salt agar and Blood agar were used to isolate *Staphylococcus aureus* (Benson, 1998). All colonies with different characteristics on their selective media were identified on the basis of their colonial, morphological and biochemical properties following Bergey's Manual of Determinative Bacteriology (Holt *et al*., 1994).

The fungi were isolated from the water samples seasonally by using two methods: The direct plate and the dilution plate, two types of growth media were used for isolation of fungi Potato dextrose agar (PDA) and Sabouraud's dextrose agar (SDA) supplemented with chloramphenicol (50 mg/l) and cycloheximide (500 mg/l). While for the isolation of fungi from soil sediment two methods were used: A dilution of 10^{-3} was chosen for the estimation of the fungal total count and the hair bait technique of Vanbreuseghem (1952) was used to isolate keratinophilic fungi. For this purpose, sterile Petri dishes were half filled with the soil samples and moistened with water and baited with burying sterile human hair in the soil. These dishes were incubated at room temperature (20 ±1 °C) and examined for fungal growth over a period of four weeks. After observing the growth under a stereoscopic binocular microscope it was cultured on SDA supplemented with chloramphenicol (50 mg/l) and cycloheximide (500 mg/l) (Deshmukh and Verekar 2006).

2.4. Statistical Analysis

Statistical analysis was conducted for the data using software program (SPSS version 20). One way ANOVA (Analysis of variance). Post hoc test (Duncan) was applied to determine significant differences in spatial and in temporal variation. All data are expressed as mean ± SE. A *P* value of 0.05 was considered as the limit for statistical significance.

3. Results and Discussion

Seasonal variation of physico-chemical and bacteriological characteristics are given in Table 1. The maximum temperature was 28 ºC recorded during summer and minimum during winter 9 ºC. The fluctuation in water temperature usually depends on the season, geographic location and sampling time.

Table 1. Seasonal variation of physico- chemical and biological characteristics of water for Duhok dam. (data represented as mean± SE).

Variables	Winter	Spring	Summer	Autumn
Water temperature (ºC)	9.0± 0.0^{a}	28± 0.0^{b}	27.1± 0.16^{c}	22± 0.0^{d}
pH	7.7± 0.057^{a}	8.3± 0.081^{b}	8.0± 0.043^{c}	7.9± 0.052^{c}
EC (µs.cm^{-1})	753± 0.88^{a}	817± 4.72^{b}	1237± 6.22^{c}	1038± 0.66^{d}
Total Nitrogen (µg.l^{-1})	18.6± 6.21^{a}	117.9± 37.7^{b}	98.6± 30.0^{b}	5.8± 2.26^{a}
Total phosphate (µg.l^{-1})	1.5± 0.31^{a}	7.98± 4.52^{a}	7.4± 3.80^{a}	0.73± 0.18^{a}
Sulphate (mg.l^{-1})	548.8± 9.93^{a}	518± 39.3^{a}	486± 39.5^{a}	579± 13.8^{a}
BOD_5(mg.l^{-1})	1.26± 0.14^{a}	1.16± 0.16^{a}	2.2± 0.15^{b}	0.93± 0.07^{a}
Heterotrophic plate count (CFU.ml^{-1})	291± 18^{a}	348000± 326^{a}	51600± 351^{a}	1296± 266^{a}
Fecal coliform MPN.100m^{-1})	1.0± 0.1^{a}	8.3± 1.3^{a}	10.6± 1.5^{a}	0.0± 0.0^{a}
Fungi (CFU.ml^{-1})	1.0± 0.05^{a}	7.6± 0.28^{b}	1.6± 0.07^{a}	2.6± 0.08^{ab}

Note: Values in each row with different letters are significantly different at $P \leq 0.05$ according to Duncan test. Values in rows with same letters are not significantly different.

Highest microorganisms counting recorded during spring and summer seasons. Statistically significant differences ($P \leq 0.05$) were observed between seasons regarding to microorganisms counts. The minimum microorganisms count in winter might be due to cold climate condition, which is not been supportive for bacterial and fungal duplication in a greater extent (Venkateesharaju *et al*., 2010).

The pH value was more than 7 and the maximum value was recorded during spring season (pH max. 8.3). High photosynthesis rate during spring adversely affect the pH value. These results came in agreement with the results of Al- Nakshabandi (2002) who also worked on Duhok reservoir. Conductivity values varied from 753 to 1237 µs. cm^{-1} for winter and summer seasons respectively. The high salt concentration of water shows that significant dissolution and/ or precipitation reactions are taking place in the lake depending upon the solubility constants of different minerals present in the lake (Millero, 2001). The minimum value observed in rainy season is due to dilution with the rain water and maximum owing to evaporation and high water temperature (Aqel, 2012). The maximum limit of conductivity value exceeds the desirable limits for drinking water (WHO, 1984). While, water quality classified as high salinity type C3 for irrigation purposes (Ayers and Wescot, 1994). Al- Nakshabandi (2002)

recorded higher electrical conductivity value for the same impoundment.

Total dissolved nitrogen and total dissolved phosphorus determination is important in assessing the potential biological productivity of surface waters, increasing concentration of phosphorus and nitrogen compounds in lakes and reservoirs leads to eutrophication (Welch and Tindell, 1992). Maximum concentration observed during Spring 117.9 and 7.98 $\mu g.l^{-1}$ for total nitrogen and total phosphorus respectively with minimum concentration recorded during autumn season.

The sulphate concentration of natural water is an important factor in determining their suitability to using it for different purposes (Sawyer and McCarty, 1978). High sulphate content recorded during studied period and never fall below 486 $mg.l^{-1}$. It exceeds maximum permissible range of Iraqi standard (1986) and WHO (2011) drinking water quality standard. Statistically significant difference ($P \leq 0.05$) was observed with conductivity value. Similar results were obtained by Al- Nakshbandi (2002) and Duhoki (1997) at the same reservoir.

BOD_5 represents the amount of oxygen that microbes need to stabilize biologically oxidizable matter. Higher BOD_5 value was recorded during Summer season (2.2 $mg.l^{-1}$). This may be due to high water temperature and bacterial counts. Statistically significant differences ($P \leq 0.05$) was found between different seasons.

High heterotrophic plate counts during all seasons were recorded with maximum number 348 x 10^3 and 51.6 x 10^3 CFU during Spring and Summer seasons respectively. The maximum permissible level of Iraqi drinking water standard must not exceed 50 $CFU.ml^{-1}$. It may reveals the human activity (Tourist and waste disposal) as bacterial population was estimated in higher concentration from water samples collected from the bank of the lake (Shafiq *et al*., 2011).

Faecal coliforms in the present investigation exhibits more counts during summer followed by spring seasons. During both seasons it exceeds Iraqi standards (1986) for drinking purposes. The presence of FC suggests that water may have been contaminated with faeces either of human or animal origin (Omezuruike *et al*., 2008).

Total fungal count was high during spring season (7.6 $CFU.ml^{-1}$), this may be related to human activities and waste disposal around lake bank.

Statistically, there are no significant differences ($P \leq 0.05$) between all studied sites for physico- chemical and biological water characteristics of Duhok reservoir (Table 2).

Table 2. Physico-chemical and biological characteristics of water for Duhok dam (data represented as mean± SE).

Locations	Seasons	Heterotrophic plate count ($CFU.gm^{-1}$)	Fecal coliform (MPN. $100m^{-1}$)	Fungi x 10^3 ($CFU.gm^{-1}$)
	Winter	$3.1x10^2$	0	21
Site 1	Spring	7×10^3	4	12
	Summer	5×10^5	4	4
	Autumn	5×10^2	0	10
	Winter	2.3×10^2	21	9
Site 3	Spring	5.2×10^5	4	13
	Summer	8×10^4	21	9
	Autumn	9×10^2	0	8

As noticed in Table 3, the results showed higher microbial count for all groups in sediment samples compared with water samples. The highest heterotrophic plate count and faecal coliform count were recorded in sediments of site 3. This site characterized by the presence of some vegetative plants near the bank. The presence of coliforms group in collected samples generally suggests that a certain selection of water and sediment samples may have been contaminated with faeces either of human and animal origin and other more dangerous microorganisms could be present (Omezuruike *et al*., 2008). Bano (2006) reported that presence of bushes, shrubs or plants makes likely possible that smaller mammals may have been coming around these water bodies to drink water, thereby passing out faeces into the water. In addition to, tourist activities nears this site that exposed to more pollutant sources.

Table 3. Seasonal variation of microbial count in sediment of Duhok dam.

Variables	Site1	Site2	Site3
Water temperature (ºC)	21.5± 4.3 [a]	21.5± 4.3 [a]	21.6± 4.4 [a]
pH	8.02± 0.11 [a]	7.96± 0.17 [a]	7.99± 0.09 [a]
EC ($\mu s.cm^{-1}$)	967± 111 [a]	960± 109 [a]	957± 109 [a]
Total Nitrogen ($mg.l^{-1}$)	80± 43.5 [a]	73.5± 32 [a]	27.1± 9 [a]
Total phosphate ($mg.l^{-1}$)	2.55± 0.9 [a]	8.63± 4.2 [a]	2± 0.5 [a]
Sulphate ($mg.l^{-1}$)	491± 36 [a]	561± 22.8 [a]	546.8± 12.6 [a]
BOD_5 ($mg.l^{-1}$)	1. 5± 0.35 [a]	1.35± 0.25 [a]	1.32± 0.26 [a]
Heterotrophic plate count (($CFU.ml^{-1}$)	18.2± 1.03 [a]	2.21± 0.81 [a]	280± 24.1 [a]
Fecal coliform MPN .$100m^{-1}$)	3.5± 2 [a]	1.75± 1.03 [a]	9.75± 4.95 [a]
Fungi ($CFU.ml^{-1}$)	3.75± 0.24 [a]	2± 0.2 [a]	4± 0.52 [a]

As shown in Table 4, *E. coli* was found in water sample almost during Winter and Summer seasons. In sediments, it was more abundant and recorded in all seasons except Autumn season. *E. coli* is the most widely adopted indicator of faecal pollution and they can also be isolated and identified simply (Kumar *et al*., 2010). *E.coli* has frequently been reported to be the causative agent of traveler's diarrhoea, urinary tract infection, hemorrhagic colitis, and haemolytic uraemic syndrome (Al-Otaibi, 2009). *Streptococcus faecalis* with *E. coli* are good indicators of gastrointestinal diseases.

The presence of such bacteria indicates the possible presence of faecal material (Leclerc *et al*., 1996). *Pseudomonas aeruginosa* has been isolated in both water and sediment samples. *Pseudomonas* can, in rare circumstances, cause community acquired pneumonias as well as ventilator associated pneumonias, being one of the most common agents isolated in several studies (Radojevic *et al.*, 2012; Fine *et al*., 1996). Karfistan and Arik-Colagolu (2005) enter *Pseudomonas* bacteria as indicators of microbiological water quality during their study on Manyas lake. *Staphylococcus aureus* regarded as important indicators of the whole aquatic ecosystem health, including fish, and birds via the food web (Kumar *et al*., 2010). Most of these isolated bacteria species from Duhok water dam have been isolated in different water bodies in other studies (Bano, 1996; Omezuruike et al., 2008; Uzoigwe and Agwa, 2012). No detection of *Vibrio cholerae* was found in water and sediment samples of Duhok water dam.

Table 5. A total of 5 fungal genera (9 species) were identified in water samples and 9 genera (12 species) were identified in sediment sample. The most dominant species includes *Aspergillus niger* (28%), *A. flavus* (16%), *A. ochracecus* and *Pencillium* spp. (10%) in water samples, while in sediment samples the most common species were *A. niger* (22%), *Rhodotorulla* spp. (19%), *A. flavus* (16%) and *Rhizopus* spp. (10%).

Higher diversity index (H`= 2.136) was accounted in sediment rather than water samples (H`= 1.956).

The fungal communities were identified at the all four seasons in water samples. The highest number of taxa, 6 species were collected in Spring season followed by 4 species in Autumn and 3 species in Summer and Winter.

In sediment samples, highest number of taxa, 8 species were observed during Autumn season, 5 species collected during Spring and Winter seasons and 4 species wereidentified during Summer. Seasonal changes in the water temperature have been shown distinct effects on occurrence and percentage of fungal communities and compositions. The reason of low fungal isolation genera in Duhok water dam may be due to absent of plants growing along its banks, with exception of few macrophytes near site 3. Luo *et al*., (2004) commented that riparian vegetation had been regarded as an important factor influencing freshwater fungal communities through availability of detritus for these organisms. Higher species isolation, occurrence and diversity index (H`) and counting in sediments than in water, may be related to availability of organic detritus on sediments that supply a good sources of food and habitat for these decomposers (El-Dohlob and Ali, 1981). It seems quite clear that the availability of organic matter, pH and water temperature play important role in the existence and propagation of aquatic fungi in lakes (Mahmoud and Abou- Zeid, 2002).

Table 4. Isolation of some bacteria in water and sediment of Duhok dam.

Samples	Bacterial isolation	Seasons												Total occurrence
		Winter			Spring			Summer			Autumn			
		Site 1	Site 2	Site3	Site 1	Site 2	Site3	Site 1	Site 2	Site3	Site 1	Site 2	Site3	
Water	*E. coli*			+				+	+	+				4
	Salmonella spp.						+	+	+	+				4
	Pseudomonas aeruginosa	+		+	+									3
	Streptococcus faecalis				+		+							2
	Staphylococcus aureus (MRSA)			+										1
	Vibrio cholera													
Total		1		3	2		2	2	2	2				14
Sediment	*E. coli*	+		+	+		+	+		+				6
	Salmonella spp.						+	+		+				3
	Pseudomonas aeruginosa	+		+										2
	Streptococcus faecalis									+				1
	Staphylococcus aureus (MRSA)	+		+						+				3
	Vibrio cholera													
Total		3		3	1		2	2		4				15

Table 5. The occurrence of fungi at different seasons in water and sediment of Duhok dam

Samples	Fungal isolation	Seasons												Total occurrence
		Winter			Spring			Summer			Autumn			
		Site 1	Site 2	Site3	Site 1	Site 2	Site3	Site 1	Site 2	Site3	Site 1	Site 2	Site3	
Water (CFU.ml^{-1})	*Aspergillus candidus*	1						1						2
	Aspergillus flavus				5		4							9
	Aspergillus niger				2	1	3		1	1	1		2	11
	Aspergillus ochraceous				4									4
	Emericella spp.	1										2		3
	Penicillium spp.		1			1						2		4
	Rhodotorulla glutins						2							2
	Cladosporium spp.						1							1
	Eurotium sp.									2			1	3
Total		2	1		11	2	10	1	1	3	1	4	3	39
Sediment x 10^3 (CFU.ml^{-1})	*Aspergillus flavus*	2		2	1		4	2		2			1	14
	Aspergillus fumigates				2									2
	Aspergillus niger			3	5		5			3			3	19
	Aspergillus ochraceous				4									4
	Cladosporium sp.										5			5
	Emericella sp.										2			2
	Mucor sp.										1			1
	Neosartoria sp.	2						2						4
	Rhizopus sp.			4						4	1			9
	Rhodotorulla sp.	17												17
	Alternaria sp.										1			1
	Penicillium citrinum						4						4	8
Total		21		9	12		13	4		9	10		8	86

Microsporum gypseum, *Chrysosporium* spp., *Trichophyton spp*. and *Absidia spp*. were isolated by hair-baiting technique (Table 6). Among the isolated species, *M. gypseum* and *Trichophyton spp*. were common agent of dermatophytosis (tinea) in human and animals that can cause many problems for human health (Hedayati and Mirzakhani, 2009. In addition, *Chrysosporium spp*. and *Absidia spp*. keratinophilic and saprophytic fungi, were isolated by this technique. These results are partially agree with that found by (Hedayati and Mirzakhani, 2009).

Table 6. Keratinophilic fungi isolated in sediment samples from different sites of water Sari city, by the hair-baiting technique.

Fungal genera	Spring	Summer	Autumn	Winter
*Absidi*a spp.			+	
Chrysosporium spp.	+	+	+	+
Microsporum spp.	+			
Trichophyton spp.			+	

4. Conclusion

High water temperature was 28 ºC recorded during Summer. All tested water samples were alkaline in their nature. Water quality characterized by high salt concentration according to electrical conductivity values, exceeded guideline standards for drinking and irrigation purposes. Sulphate content exceeded Iraqi standard for drinking water quality and may be attributed to some sulphur springs discharged into Duhok water dam. Fecal coliform group was detected in all studied sites. Higher microbial count, isolation and diversity index were found in sediment rather than water samples. This may be related to organic detritus which used as microhabitat and food sources for microbial growth. Isolation of some pathogenic microorganisms (bacteria and fungi) in water and sediment samples, may be due to non point sources of pollutant discharged into Duhok water dam, can cause problems for human health as used for drinking and swimming activities. Fourteen fungal genera were isolated during this investigation.

References

Akbulut M, Kaya H, Celik ES, Odabasi DA, Odabasi SS and Selvi K. 2010. Assessment of surface water quality in Atikhisar reservoir and Saricay creek (Canakkale, Turkey). *Ekiloji*. 19, **74**: 139- 149.

Al- Gabani HA. 1985. Duhok city , a study in urban geography. MSc. Thesis- Mosul University-Iraq. pp.102.

Al- Nakshbandi IZR. 2002. A phycologicalstudy on Duhok impoundment its main watershed. PhD Dissertation- Duhok University-Iraq. pp.143.

Al-Otaibi EL. 2009. Bacteriological assessment of urban water resources in KhamisMushait governorate, southwestern Saudi Arabia. *Inter J Health Geographics.* **8**:16.

American Public Health Association (A.P.H.A.) 1998. **Standard methods for the examination of water and wastewater**. Twentieth ed. A.P.H.A.,1015 Fifteenth Street, NW, Washington, DC. 20005-2605.

Aqel H. 2012. Prelimnary investigation on the chemical, physical and microbiological properties of Dumat lake in Al- Jouf region, Saudi Arabia. *Eur J Biological Sci*., **4(1):** 5- 12.

Ayers R S and Westcot D. W. 1994. Water Quality for Agriculture, FAO Irrigation and Drainage Paper 29, revision 1, Food and Agriculture Organization of United Nations, Rome, Italy.

Bano K. 2006. Nutrient load and pollution study of some selected station along Ogunpa river in Ibadan, Nigeria. M.Sc Dissertation. University of Ibadan, Nigeria.

Benson HJ. 1998. **Microbiological applications: Laboratory manual in general Microbiology**, seventh edition, pp. 208-211.

Collee JG, Frasher AG, Marmion BP and Simmons A. 1996. **Mackie and McCartney Practical Medical Microbiology.** Fourteenth Edition, Churchill Living Stone

Deshmukh S K and Verekar S A. 2006. The occurrence of dermatophytes and other keratinophilic fungi from the soils of Himachal Pradesh (India). *Czech Mycol*., **58(1–2):** 117–124.

Dohuki MSS. 1997. Classification of some wells and springs water in Duhok governorate for irrigation purposes. M.Sc. Thesis. University of Duhok, Iraq.

El-Dohlob M and Ali BZ. 1981. Fungal population inhabiting polluted water of the river Shatt Al-Arab and its creek at Basrah, Iraq. *J. of Univ. of Kuwait*: 235- 241.

Fine MJ, Smith MA and Carson CA. 1996. Prognosis outcome of patient with community acquired pneumonia. *JAMA*. **275 (2):** 134- 141.

Hedayati MT and Mirzakhani M. 2009. Survey of keratinophilic fungi in sewage sludge from wastewater treatment plants of Mazandaran, Islamic Republic of Iran. *Eastern Mediterranean Health J.*, **15(2):** 451-454.

Holt JG, Krieg NR, Senath PHA, Staley JT and Williams ST 1994. **Bergey's Manual of Determinative Bacteriology**. Ninth Edition. Baltimore Md.,Willaims and Wilkins.

Iraqi Standards. 1986. Environmental legislation. Iraqi Directorate for Environment Protection and Improvement. Ministry of Health. Baghdad-Iraq.

Karafistan A and Arik- Colakoglu F. 2005. Physical, chemical and microbiological water quality of the Manyas lake, Turkey. *Mitigation and adaptation Strategies for Global Change*. **10:**127 -143.

Kumar A, Bisht BS, JoshiVD, Singh AK and Talwer A. 2010. Physical, chemical and bacteriological study of water from river of Uttarakhand. *J Human Ecol*.. **32(3):** 169- 173.

Leclerc H, Devriese LA and Mossel DAA. 1996. Taxonomical changes in intestinal (faecal) enterococci and streptococci: Consequences on their us as indicators of faecal contamination in drinking water. *J. Appl. Bacteriol*., **81**:459- 466.

Lind OT. 1979. **Handbook of common methods in limnology**. C.V. Company. USA. pp 197.

Liu W, Yu H and Chung C. 2011. Assessment of water quality in a subtropical Alpine lake using multivariate statistical techniques and geostatistical mapping: A case study. *Inter J Environ Res Public Health*. **8:** 1126-1140.

Luo J, Yin J, Cai L, Zhang K and Hyde KD. 2004. Freshwater fungi in lakeDianchi, a heavily polluted lake in Yunnan, *China. Fungal Diversity*. **16 :** 93-112.

Mackereth FJ.H, Heron J and Talling JF. 1978. **Water Analysis: Some Revised Methods For Limnologists Science Publication**. No. 36. Freshwater Biol. Assoc., Titus Wilson and SonsLtd. UK. pp 121.

Mahmoud Y A G and Abou- Zeid A M. 2002. Zoo sporic fungi isolated from four Egyptian lakes and the uptake of radioactive waste. *Mycology*. **30(2):**76- 81.

Millero FJ. 2001. **The Physical Chemistry of Natural Waters**. Wiley- Interscience, New York.

Mustafa YT and Noori MJ. 2013. Satellite remote sensing and geographic information systems (GIS) to assess changes in the water level in the Duhok dam. *Inter J Water Resources and Environ Eng*., **5(6),** 351-359**.**

Omezuruike OI, Damilola AO, Adeola OT, Fajobi EA and Shittu OB. 2008. Microbiological and physico- chemical analysis of different water samples used for domestic purposes in Abeokuta and ojota, Lagos state, Nigeria. *Afr J Biotechnol.*. **7(5):** 617- 621.

Pejman AH, NabiBidhendi GR, Karbassi AR, Mehrdadi N and Esmaeili Bidhendi M. 2009. Evaluation of spatial and seasonal variations in surface water quality using multivariate statistical techniques. *Inter. J. of Environ. Sci Technol.*, **6(3):** 467- 476.

Pisinaris V, Petulas C, Gemitzi A and Tsihrintz VA. 2007. Water quantity and quality monitoring of Kosynthosriver, norh- eastern Greece. *Global Nest J*., **9(3):** 259- 268.

Radojevic ID, Stefanovic DM, Comic LR, Ostojic AM, Topuzovic MD and Strfanovic ND. 2012. Total coliforms and data mining as a tool in water quality monitoring. *Afr J Microbiol Res*., **6(10):** 2346- 2356.

Rompre A,ServiasP, Baudart J,de-Roubin M and Laurent P. 2002. Detection and enumeration of coliforms in drinking water. Current methods and emerging approaches. *J Microbiol Methods*, **49:**31-54

Sawyer CN and McCarthy PL. 1978. **Chemistry for Environmental Engineering**. 3rd Ed. McGraw-Hill Book Company. Singapore. pp. 532.

Shafiq HB, Ajaz M and Rasool SA. 2011. Bacterial and toxic pollutants in lake of river Indus. *Pak J of Botany*, **43(3):** 1765-1772.

Sugita H, Okamoto N and Nakamura T. 1993. Characterization of microaerophilic bacteria isolated from the coasted waters of of Tokyo Bay, Japan. *FEMS Microbiol Ecol.*, **13:** 37-46.

Ulfig K and Korcz M G. 1991. keratynofilnewosadachsciekowych [Keratinophilic fungi in wastewater sediments]. *Roczniki Panstwowego ZakladuHigieny*, **42:** 309–15.

Uzoigwe CI and Agwa OK. 2012. Microbiological quality of water collected from boreholes sited near refuse dumpsites in Port Harcourt, Nigeria. *Afr J Biotechnol.,* **11(13):** 3135- 3139.

Vanbreuseghem R. 1952. Technique biologique pour 1'isolement des dermatophytes du *sol*. – *Ann. Soc. Belge. Med. Trop*. **32:** 173–178.

Venkatesharaju K, Ravikumar P, Somashekar R K and Prakash KL. 2010. Physico- chemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. *Kathmandu University J Sci, Eng Technol*., **6 (1):** 50- 59.

Welch E.B. and Lindell T. 1992**. Ecological Effects of Wastewater: Applied Limnology and Pollutant Effects**. 2nd Ed., Taylor and Francis Group LLC. pp.419.

WHO. 1984. Guidelines for drinking water quality recommendation. *World Health Organization*. Geneva.**1:** 130.

WHO. 2008. Guidelines for drinking water quality (3rdEd.). Incorporating first and second addenda. World Health Organization Press, Switzerland. **1:** 281- 294.

WHO. 2011. Guidelines for drinking water quality. 4th.Ed. NML. Classification: WA **675:** 541.

Wikipedia. 2008. "Iraqi Dam Assessments". Iraq: United States Army, Corps of Engineers. 6 June 2003. Retrieved 27 February 2012.http://en.wikipedia.org/wiki/Dohuk_Dam