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A comparative physiochemical and microbial investigation on water of two ground water plants in Menoufia – Egypt before and after treatment

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The surface water contains some dissolved contaminants such as iron and manganese salts where the ground water contains ammonia besides the two mentioned ions; hence they are unsuitable as drinking water without appropriate treatment. This study was carried out during the period from February to December 2019. The aim of this work was to make a comparison between certain physicochemical and microbial parameters at two different ground water plants Dalaton (River bank filteration) and Meet Khaqan (conventional ground water plant) in Menoufia Governorate, Egypt. Confirming to data of the physicochemical parameters, the treated water at these treatment plants proved a remarkable enhancement as compared with raw one mainly with the value of TDS, conductivity, turbidity, total alkalinity, iron, manganese and ammonia but treated water for Meet Khaqan plant showed high turbidity ranged from 0.7 NTU to 1.0 NTU compared with Dalaton plant (ranged between 0.16 NTU and 0.65 NTU). For Meet Khaqan plant TDS had high values ranged between 772 and 915 ppm while for Dalaton it ranged from 214 to 270 ppm. Regarding biotic component, it was proved that both total and fecal coliform and algea disappeared more or less completely at the end of the water treatment process in both plants. On the other hand algal examination showed that, there wasn't any phytoplankton in ground water in Meet Khaqan water while Dalaton water plant (River bank filtration) showed anumber of phytoplankton populations in both raw and treated water belonging to three groups namely: Bacillariophyta, Chlorophyta and Cyanophycta. Bacillariophyta represented the most abundant group accounting 76.8 % of total annual crop. Chlorophyta ranked as the 2nd group with 13.8%. Finally, Cyanophyta ranked as 3rd group with 2.7% of total annual crop. From the practical and statistical point of views, it could be possible to conclude that the river-bank filtration (Dalaton) was the most effective method to obtain better potable water.

Keywords: Ground water, Iron, Manganese, River bank filtration, T.D.S, Total coliform, Algea.

INTRODUCTION

The majority of common water systems about (90%) are supplied by ground water; however, more than (68%) of persons were supplied by community water systems that use surface water (EPA, 2008). People use surface and ground water every day for different purposes, including drinking, cooking and basic hygiene, also for agricultural and industrial activities. Effort should be made to achieve drinking water quality as high as practicable, otherwise people life are extremely subjected to hazardous effects. Proper selection and protection of water sources to be used for supplying water treatment systems are of prime importance in the provision of safe drinking water (Liu and Jones, 1995)**.** Unfortunately, Nile ecosystem is currently suffering from the discharge of contaminated agricultural wastewater, oil discharge and untreated domestic wastewater (Ali and El Shehawy, 2017). The ground water is considered a secondary source to irrigate some agricultural areas in the Delta region, and as a main source for some cultivated lands to which the Nile water is not reachable. In many parts of Egypt, the ground water is widely used for drinking and other domestic purposes (Fahim *et al*., 1995; Soltan, 1998 and Mamdouh *et al*., 2003). Ground water is characterized by high level of total dissolved solids that resulting from drains downward through many deep layers of minerals also ground water is mostly used without treatment stages process except physicochemical ones that made to remove and eliminate non desirable taste and odors**.** Ground water includes two types: firstly, water that drains downward (percolates) below the root zone finally reaches a level at which all the openings are filled with water. This zone is called the zone of saturation; the water in the zone of saturation is called the ground water which characterized by high level of total dissolved solids that resulting from drains downward through many deep layers of minerals (Bouita *et al*., 2021). Secondly, River bank filtration is the infiltration of surface water, mostly from a river system into a

groundwater system induced by water absorption close to the surface water (a river bank). This water abstraction is commonly done by operating wells, as the water flows through the soil, it is filtered and hence its quality is improved. In the context of developing or newly-industrialized countries, bank filtration may lead to a more sustainable water cycle by recharging stressed groundwater bodies with filtered surface water (Huelshoff *et al*., 2009)**.** Drilled near rivers and lakes, bank filtration wells withdrawal surface water through soil and aquifer material, which serves as a passive treatment reactor. As the surface water moves through the aquifer, it is subjected to filtration, dilution, sorption, and biodegradation processes (Gollnitz *et al*., 2003). Drinking water has to be clear and free from objectionable tastes, odors, harmful chemicals and microorganisms of these desired sanitary qualities (Ali *et al.,* 2010). To investigate both of water quality and ecology variations of the water body we should measure both of the physical and chemical parameters (Temperature, Turbidity, Total dissolved salts, Electrical conductivity, pH, Dissolved Oxygen, Total alkalinity, Total hardness, Calcium hardness, Magnesium hardness, Chlorides, Iron, Manganese, Sulfate, Nitrate, Ammonia and Phosphate). (Shabaan *et al.,* 1999; Shaaban *et al*., 2019). The main source of microbiological contamination are microorganisms from human or animal excreta, which approach humans through contaminated groundwater from wastewater, landfills, or wastewater treatment stations causing serious health problems (Goshu*, et al.,* 2021). For example, according to the UN, diarrhea accounts for 80% of all diseases and over one third of deaths in developing countries, which are caused by the patients' drinking of contaminated water (Mostafa *et al*., 2013). The bacteriological examination of water is particularly important as it remains the most sensitive method for detecting fecal and, therefore, potentially dangerous contamination (Al-Khatib and Hassan, 2009). Total coliforms and fecal coliforms are indicator bacteria that have been used for decades to infer the presence of other potentially harmful pathogens in recreational waters. When large number of indicator bacteria is present in the water, it is assumed that there is a greater likelihood that pathogens are present (Singh *et al.,* 2021). The fecal coliform bacteria a subgroup of the total coliform populations have a direct correlation with fecal contamination from warm-blooded animals (Geldreich *et al*., 1972). Changes in plankton's abundance, community composition or species diversity constitute a potential bio-indicator of water quality and problems in response to local pollution or disturbance (El-Otify and Iskaros, 2015). Phytoplankton are photosynthetic, meaning they have the ability to use sunlight to convert carbon dioxide and water into energy (Southard *et al.,* 2006) so as they need light, phytoplankton in any environment will float near the top of the water to have sunlight. The more nutrients (particularly phosphorous) that are present in the water the more algae and phytoplankton that will grow**.** As photosynthesis production increase, so will phytoplankton reproduction rates .Most freshwater phytoplankton are consist of green algae and cyanobacteria and also known as blue green algae (Hickin, 1995).

MATERIALS AND METHODS

Sampling procedure

Water samples from two ground water plants (Meet Khaqan and Dalaton) Menoufia Governorate were collected monthly from Februray to December 2019. All water samples were collected according to standards mentioned in (APHA, 1998).Samples were preserved immediately after collection by acidifying to pH<2 by adding 5 ml nitric acid to 1 liter water samples and preserved in refrigerator. Samples for bacteriological analysis were collected in 500 ml sterilized glass bottles having dechlorination agent (sodium thiosulfate $Na_2S_2O_3$ 3% solution) while samples for algal examination were collected in 1000 ml glass containers and fixed with standard Lugol's solution.

Phytoplanktonic examination

The samples were concentrated by membrane filtration using Sartorius SM 16828 membrane filter and centrifugation technique at 1000 g for 20 min using MPW – 350e centrifuge (APHA, 2010). The phytoplanktonic algae were counted using standard microscope by Sedgwick Rafter cell. One ml of concentrated sample was pipetted on Rafter cell and examined under standard microscope. Sedgwick Rafter cell is a slide with 1 mm, of 1,000 mm^2 area and volume of 1.0 ml. Algal species were identified according to Bourrelly, (1968); Prescott, (1982); Starmach, (1984); Tikkanen, (1986); Popovsky and Pfiester, (1990); Compère, (1991); Krammer and Bertalot, (1991).

Estimation of physicochemical parameters

Physicochemical parameters were estimated according to standard methods for examination of water and wastewater 22nd edition. Turbidity was measured using a digital turbidity meter (WTW Turb550).Alkalinity was estimated by titration method against 0.02 N sulfuric acid (APHA, 2010). Total dissolved salts and conductivity were measured directly by using a digital meter (Conductivity meter selecta).pH value was measured by a digital pH meter (Metrohm 827 PH lab). Chlorides were titrated against $AgNO_3$ (Kolthoff and Stenger, 1947) Manganese was detected by the persulfate method (Mills, 1950). Ammonia was measured by Nessler method (Standard method 19th edition).Sulfate was estimated with the turbid metric method (Thomas and Cotton, 1954). Phosphate was estimated by stannous chloride method (Strickland and Parsons, 1965).Nitrate determined by UV spectrophotometric screening method (Navone, 1964). Iron was estimated by phenanthroline method (Duncan,

1979). Calcium hardness was measured by EDTA titrimetric method (APHA, 2010).Total hardness was measured by titration method against EDTA (Olmsted and Williams, 1997).

Bacteriological analysis

Detection and enumeration of total coliform using m-Endo LES agar medium (Difco). Fecal Coliform using m-FC agar (Merck) (Green *et al.*, 1980) and fecal streptococcus using m- Enterococcus agar (Gross *et al*., 1975) were determined by membrane filter technique (APHA, 2010) using membrane filter apparatus (Sartorius SM 16828) which depends on sample filtration through a 0.45µm pore size cellulose membrane filters that retain the bacteria present in the sample. The filters were put onto the medium, using a rolling action to avoid trapping air bubbles between the membrane filter and the underlying medium. The plates were inverted and incubated at 35 ± 0.5 ºC for 22h in incubator, incubated at 44.5 ± 0.2 ºC for 24h in water bath and incubated at 35 ± 0.5 ºC for 48h in incubator respectively. Detection and enumeration of heterotrophic bacteria by heterotrophic plate count test (HPC) by pour plate method by using R2A agar media (Merck). The plates were inverted and incubated at 35 ± 0.5 ºC for 48h (Means *et al*., 1981).

RESULTS

Bacteriological analysis

Total coliform bacteria

As Shown in table (1) the number of total coliform bacteria in raw surface water and in raw ground water was ranged between <1 and 22500 total coliform /100ml , the lowest value recorded at G2 (Meet Khaqan raw ground water) in (February, April, June and December). The annual average of Dalaton raw ground water was (14616.7 total coliform /100ml) while in Meet Khaqan ground raw water, was (91total coliform /100ml). All treated ground water samples show negative results. The annual average of both plants treated water was (0.01 total coliform /100ml).

Table (1): Total coliform /100 ml of raw and treated water at Meet Khaqan and Dalton during period of study

Tested locations / ***Months***	***G1***		***G2***	
Sample	***R***	***T***	***R***	***T***
February	8200	<1	<1	<1
April	17000	<1	<1	<1
June	20000	<1	<1	<1
August	22500	<1	82	<1
October	11200	<1	100	<1
December	8800	<1	<1	<1
Annual average	14616.7	0.01	91	0.01
SD	6057.86	0.00	47.33	0.00
P-value	**P1=0.00** P3=0.00** P4=0.148**			

R: Raw water **T**: treated water **<1**: Negative result
G1: Dalton ground water plant **G2**: Meet khaqan ground
P1: Raw vs raw **P2**: Treated vs treated
P3: Raw vs treated in Dalton **P4**: Raw vs treatd in Meet Khaqan

Fecal coliform bacteria

As recorded in table (2), the number of fecal coliform bacteria in raw surface water was ranged between <1 and 9000 fecal coliform /100 ml, the lowest value was recorded at G2 (Meet khaqan ground raw water) in all months. The highest value was at G1 (Dalton raw ground water) in August. All treated ground water samples showed negative results. The annual average of Dalaton ground raw water was (4883.3 fecal coliform /100ml) while in Meet Khaqan ground raw water, was (0.01 fecal coliform /100ml). All treated ground water samples show negative results.

Table (2): Fecal coliform /100 ml of raw and treated ground water at Meet Khaqan and Dalaton during the period of study

Tested locations / ***Months***	***G1***		***G2***	
Sample	***R***	***T***	***R***	***T***
February	1000	<1	<1	<1
April	2000	<1	<1	<1
June	8900	<1	<1	<1
August	9000	<1	<1	<1
October	3800	<1	<1	<1
December	4600	<1	<1	<1
Annual average	4883.3	0.01	0.01	0.01
SD	3397.89	0.00	0.00	0.00
P-value	**P1=0.006* P3 =0.006***			

R: Raw water **<1:** Negative result **T:** treated water
G1: Dalton ground water plant **P1:** Raw vs raw
G2: Meet khaqan ground water plant
P2: Treated vs treated **P3:** Raw vs treated in Dalton
P4: Raw vs treatd in Meet Khaqan

Fecal Streptococcus bacteria

As recorded in table (3), the number of fecal *Streptococcus* bacteria in raw ground water ranged between <1 and 346 Fecal *Streptococcus* /100ml. The lowest value was recorded at G2 (Meet Khaqan raw ground water) in all months. The highest value was at G1 (Dalaton raw ground water) in August. The annual average of Dalaton raw ground water was (258.8 Fecal *Streptococcus* coliform /100ml) while in Meet Khaqan raw ground water, was (0.01Fecal *Streptococcus* coliform /100ml). All treated ground water samples showed negative results.

Table (3): Fecal *Streptococcus* coliform /100 ml of raw and treated ground water at Meet Khaqan and Dalaton during period of study

Tested locations Months	*G1*		*G2*	
Sample	*R*	*T*	*R*	*T*
February	180	<1	<1	<1
April	288	<1	<1	<1
June	334	<1	<1	<1
August	346	<1	<1	<1
October	213	<1	<1	<1
December	192	<1	<1	<1
Annual average	258.8	0.01	0.01	0.01
SD	73.32	0.00	0.00	0.00
P-value	**P1=0.00** P3 =0.00****			

R: Raw water **<1:** Negative result **T:** treated water **G1:** Dalaton ground water plant **G2:** Meet khaqan ground **P1:** Raw vs raw **P3:** Raw vs treated in Dalaton

Heterotrophic plate count (HPC):

As recorded in table (4), the number of heterotrophic bacteria in raw ground water was ranged from 38 to 1.84×10^5 CFU / ml. The lowest value was recorded at G2 (Meet Khaqan treated water) in February. The highest value was at G1 (Dalaton raw ground water) in August. The annual average of HPC in Dalton raw ground water was (1.5×10^5) while in Meet Khaqan raw water, was (1.37×10^2 CFU / ml). Treated ground water was ranged from 2 to 1.66×10^2 CFU / ml. The lowest value was recorded at G2 (Meet Khaqan treated ground water) in February. The highest value was at G1 (Dalaton treated ground water) in August. The annual average of HPC in Dalton treated ground water was (78.3 CFU / ml) while in Meet Khaqan treated ground water was (22.5 CFU / ml).

Table (4): Heterotrophic plate count (HPC) CFU / ml of raw and treated ground water at Meet Khaqan and Dalaton during period of study

Tested locations Months	*G1*		*G2*	
Sample	*R*	*T*	*R*	*T*
February	9.2×10^4	38	38	2
April	1.79×10^5	72	49	8
June	1.81×10^5	50	61	12
August	1.84×10^5	166	240	48
October	1.72×10^5	99	360	55
December	9.4×10^4	45	72	10
Annual average	1.5×10^5	78.3	136.7	22.5
SD	4.46×10^4	1.94	1.5×10^5	22.37
P-value	**P1=0.049* P2=0.001* P3=0.00** P4=0.001***			

R: Raw water **<1***: Negative result* ***T:*** treated water ***G1:*** Dalaton ground water plant **G2**: Meet khaqan ground **P1:** Raw vs raw **P2:** Treated vs treated **P3**: Raw vs treated in Dalaton **P4:** Raw vs treatd in Meet Khaqan

Physicochemical parameters

As illustrated in Table (5), water temperature of Dalaton ground water plant was ranged from 20°C to 29.3°C while in Meet Khaqan water plant, ranged from 19°C to 30.1°C. Turbidity was ranged from 0.19 to 12 NTU in Dalton while in Meet Khaqan water plant, ranged from 0.82 to 12.8 NTU. TDS and conductivity were ranged from 226 to 297 ppm, 361 to 475µS/cm, respectively in Dalaton ground water plant while in Meet Khaqan water plant, ranged from 779 to 784 ppm, 928 to 1434 µS /cm, respectively. The pH of Dalaton ground water plant ranged from 7.1 to 7.8 while its range in Meet Khaqan, was from 7.4 to 8.1. The range of magnesium hardness was from 35 to 90 ppm in Dalaton while in Meet Khaqan, its range from 90 to 141 ppm. Magnesium ions concentration ranged from 3.96 to 21.6 ppm in Dalaton ground water plant while in Meet Khaqan, it ranged from 21.6 to 33.8 ppm. Iron was ranged from 0.01 to 0.16 ppm in Dalaton while in Meet Khaqan ranged from 0.24 to 0.86 ppm. Manganese in Dalaton ranged from 0.01 to 0.16 ppm while in Meet Khaqan ranged from 0.21 to 1.2 ppm. The range of sulfate in Dalaton was from 24 to 40 ppm while in Meet Khaqan, was from 32 to 47 ppm. Phosphate concentration was from 0.21 to 0.55 ppm in Dalaton while in Meet Khaqn, was from 0.21 to 0.46 ppm. In Dalaton nitrate ranged from 0.15 to 0.67 ppm while in Meet Khaqan ranged from <0.01 to 2.1 ppm. Finally, ammonia in Dalaton ranged from 0.11 to 0.48 ppm while in Meet Khaqan ranged from 0.1 to 0.48ppm.

Table (5): The physico-chemical parameters of raw and treated ground water at Meet Khaqan and Dalton during the period of study

Month	February				April				June				August				October				December			
Water Plant / Parameter	G1		G2		G1		G2		G1		G2		G1		G2		G1		G2		G1		G2	
Sample	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
Temperature°C	20.3	20	21	21.1	22.4	22.1	23	23.2	29.3	28.8	29.1	29.3	28.5	28.1	30	30.1	24.7	24.1	24	24.2	20.2	20	19	19.2
Turbidity(NTU)	10.5	0.65	0.5	0.85	11.4	0.33	0.56	0.9	10.2	0.28	0.87	1	10	0.29	0.4	0.82	11	0.27	0.63	0.91	9.7	0.16	0.44	0.7
pH	7.7	7.3	7.82	7.49	7.8	7.2	7.91	7.58	7.8	7.5	7.73	7.4	7.7	7.1	7.9	7.5	7.8	7.4	7.8	7.4	7.7	7.2	8.1	7.7
TDS(mg/L)	270	263	779	772	230	224	858	842	240	236	920	915	226	214	849	831	274	270	805	800	270	263	869	864
(µS/Cm)Conductivity	435	475	1238	1246	368	374	1429	1434	384	393	1358	1365	361	368	1260	1264	438	443	1310	1312	432	436	928	1026
Iron(mg/L)	0.01	0.01	0.29	0.17	0.16	0.15	0.33	0.24	0.01	0.01	0.45	0.39	0.11	0.1	0.86	0.73	0.01	0.01	0.41	0.3	0.01	0.01	0.7	0.5
Manganese(mg/L)	0.01	0.01	0.62	0.58	0.16	0.16	1.2	1.07	0.13	0.11	0.38	0.35	0.01	0.01	0.8	0.78	0.01	0.01	0.3	0.21	0.01	0.01	0.32	0.28
Total hardness(mg/L)	150	145	428	420	158	155	430	425	159	156	381	370	180	175	366	360	160	161	433	430	170	168	418	410
Ca. hardness(mg/L)	110	110	287	280	116	109	300	290	96	80	241	230	90	100	273	270	80	70	310	300	100	100	317	310
Mg. hardness(mg/L)	40	35	141	140	42	46	130	135	63	76	140	140	90	75	93	90	80	90	123	130	70	68	101	100
Ca^{+2}(mg/L)	44	44	114	112	46.4	43.6	120	116	38.4	32	96	92	36	40	109	108	32	28	124	120	40	40	126	124
Mg^{+2}(mg/L)	9.6	8.4	33.8	33.6	3.96	11.04	31.2	32.4	15.1	18.2	33.6	33.5	21.6	18	22.3	21.6	19.2	21.6	29.5	31.2	16.8	16.32	24.2	24
Total Alkalinity(mg/L)	180	170	448	440	154	150	365	360	172	170	461	450	170	168	488	480	160	158	471	460	180	175	412	400
Chlorides(mg/L)	30	50	119	125	22	34	126	130	23	35	164	170	21	35	107	110	28	39	123	130	23	50	115	120
Sulfate(mg/L)	26	29	41	46	24	40	33	38	35	42	36	40	27	38	42	47	28	36	32	39	29	35	40	45
Phosphate(mg/L)	0.36	0.34	0.3	0.24	0.31	0.22	0.21	0.17	0.32	0.21	0.44	0.39	0.45	0.52	0.33	0.29	0.55	0.47	0.46	0.4	0.43	0.32	0.39	0.36
Nitrate(mg/L)	0.3	0.15	0.11	<0.01	0.35	0.25	2.1	1.6	0.55	0.2	0.83	0.74	0.64	0.43	0.71	0.63	0.67	0.52	1.1	0.98	0.55	0.31	1.9	1
Ammonia(mg/L)	0.34	0.32	0.28	0.11	0.12	0.11	0.31	0.1	0.42	0.24	0.43	0.21	0.38	0.31	0.48	0.25	0.48	0.3	0.3	0.18	0.36	0.25	0.29	0.13

. ***Ca. hardness: - Calcium hardness*** ***Mg. hardness: - Magnesium hardnes***
G1: Dalton ground water plant ***G2: Meet khaqan ground***

Sample	RG1		TG1		RG2		TG2		P-value			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P1	P2	P3	P4
Temperature (C)	24.23	3.98	23.85	3.88	24.35	4.39	24.52	4.38	0.962	0.786	0.869	0.949
(NTU)Turbidity	10.47	0.64	0.33	0.17	0.57	0.17	0.86	0.10	0.000	0.000	0.000	0.004
pH	7.75	0.05	7.28	0.15	7.88	0.13	7.51	0.11	0.050	0.013	0.000	0.000
(mg/L) TDS	251.67	22.07	245.00	23.48	846.67	49.65	837.33	49.93	0.000	0.000	0.623	0.752
Conductivity(µS/Cm)	403.00	35.89	414.83	42.89	1253.83	173.86	1274.50	139.79	0.000	0.000	0.616	0.825
(mg/L) Iron	0.05	0.07	0.05	0.06	0.51	0.22	0.39	0.20	0.001	0.003	0.930	0.362
Manganese (mg/L)	0.06	0.07	0.05	0.07	0.60	0.35	0.55	0.33	0.004	0.005	0.934	0.774
(mg/L) Total hardness	162.83	10.55	160.00	10.55	409.33	28.61	402.50	29.96	0.000	0.000	0.652	0.695
(mg/L) Ca. hardness	98.67	13.13	94.83	16.25	288.00	27.94	280.00	28.28	0.000	0.000	0.663	0.633
(mg/L) Mg. hardness	64.17	20.14	65.00	20.57	121.33	20.15	122.50	21.85	0.001	0.001	0.945	0.925
Ca2+(mg/L)	39.47	5.25	37.93	6.50	114.83	11.18	112.00	11.31	0.000	0.000	0.663	0.672
Mg2+ (mg/L)	14.38	6.53	15.59	4.93	29.10	4.84	29.38	5.23	0.001	0.001	0.723	0.924
(mg/L) Total Alkalinity	169.33	10.56	165.17	9.30	440.83	45.11	431.67	44.01	0.000	0.000	0.485	0.729
(mg/L) Chlorides	24.50	3.62	40.50	7.56	125.67	19.92	130.83	20.60	0.000	0.000	0.001	0.668
(mg/L) Sulphate	28.17	3.76	36.67	4.55	37.33	4.27	42.50	3.94	0.003	0.039	0.005	0.054
(mg/L) Phosphate	0.40	0.09	0.35	0.13	0.36	0.09	0.31	0.09	0.388	0.562	0.396	0.404
(mg/L) Nitrate	0.51	0.15	0.31	0.14	1.13	0.75	0.86	0.47	0.079	0.020	0.040	0.478
(mg/L) Ammonia	0.35	0.12	0.26	0.08	0.35	0.08	0.16	0.06	0.979	0.046	0.142	0.001

P1: *Raw vs raw* ***P2:*** *Treated vs treated* ***P3:*** *Raw vs treated in Dalton* ***P4:*** Raw vs treatd in Meet khaqan

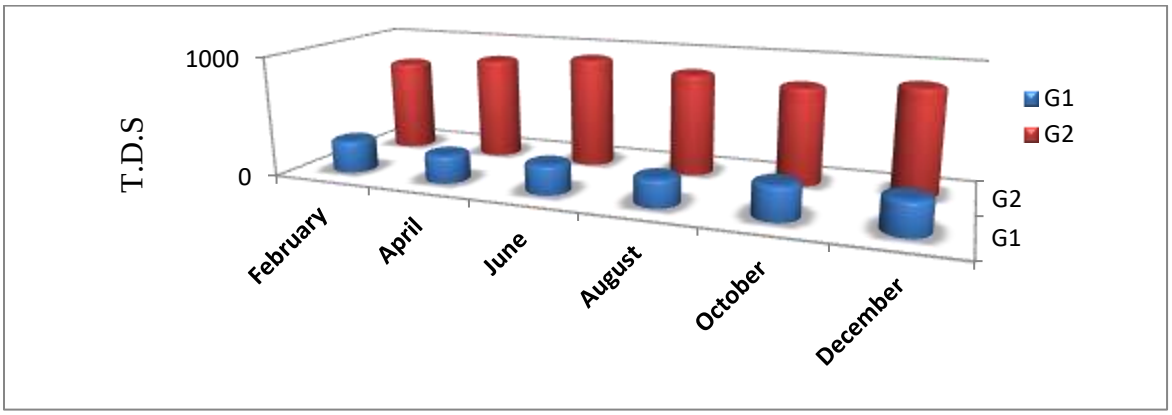

Figure (5a): TDS of raw and treated ground water at Meet Khaqan and Dalaton during the period of study.

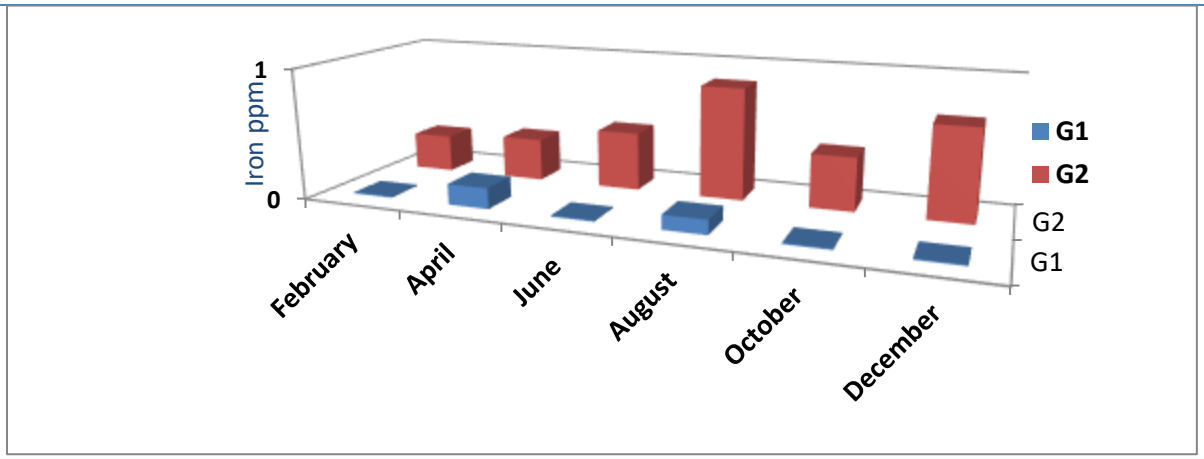

Figure (5b): Iron of raw and treated ground water at Meet Khaqan and Dalaton during the period of study.

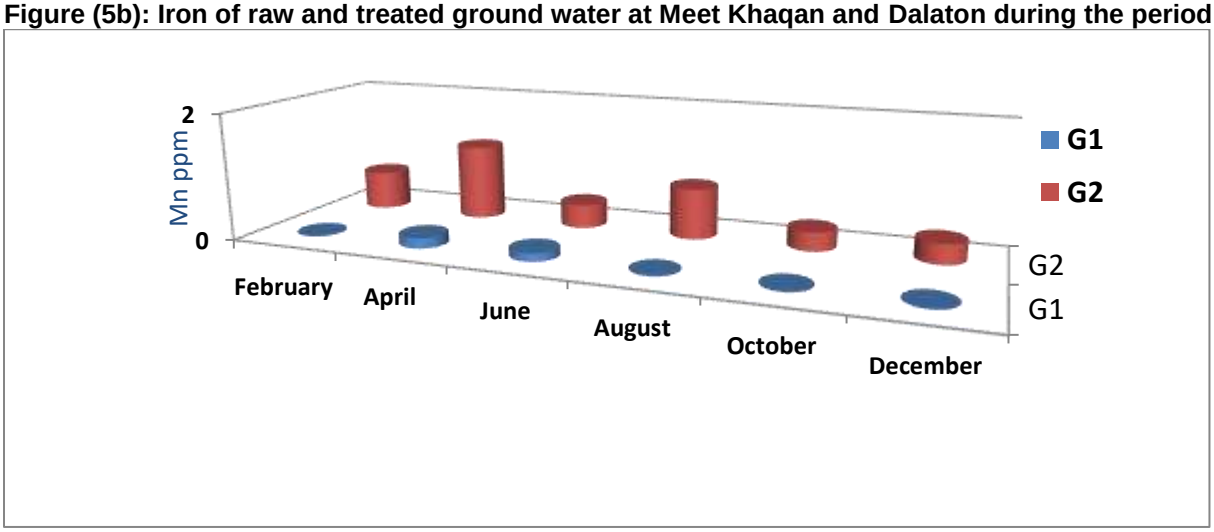

Figure (5c): Manganese of raw and treated ground water at Meet Khaqan and Dalaton during the period of study.

Seasonal distribution of phytoplankton

Algal examination was performed to ground water in Meet Khaqan water plant during the period of study and the results showed that, there wasn't any phytoplankton in ground water, while Dalaton water plant (Bank river filtration) showed a number of phytoplankton populations per year in both raw and treated water.

Raw water of Dalton ground water plant

As shown in table (6) and represented in figure (6) the total number of phytoplankton populations throughout the period of study per year in Dalaton water plant was (595×10^3 organisms /L). The highest yield was (1.88×10^5 organisms /L) in February followed by April and October with yield of (163×10^5) $\times10^3$organisms /L, respectively. On the other hand, the minimum yield was (2.8×10^4 organisms /L) in August. June and December showed moderate values (7.8×10^4) organisms /L. As illustrated in table (7) and represented in figure (7) the phytoplankton populations encountered in Dalaton water plant are included in the divisions of Bacillariophyta, Chlorophyta and Cyanophyta. Bacillariophyta dominated the whole populations, as it accounted for 76.8 % of total annual crop with annual average of species number 5.8×10^3 organisms/ L. Chlorophyta ranked as the 2nd division with 13.8 % of total annual crop with annual average of species number 2.2×10^3 organisms/ L, and then followed by Cyanophyta with 2.7 % of total annual crop with annual average of species number 1.7×10^3 organisms/ L. The range, average and seasonal variation of the recorded groups are represented in figures 7(a, b, c and d) and can be summarized as the following:-

Bacillariophyta

Bacillariophyta attained the maximum accumulation (1.51×10^5 organisms /L) in February followed by April with total count (1.38×10^5 organisms/ L). The minimum occurrence was (28×10^3 organisms/ L) in August followed by December (4.8×10^4 organisms/ l). April and June showed moderate occurrence of Bacillariophyta (1.39×10^5 organisms/ L, respectively. The most common species of Bacillariophyta was *Cyclotella Comta* with (1.77×10^5 organisms/ L) total number per year

with high rank of occurrence. Followed by, *Cyclotella kutzingiana* with (1.55×10^5 organisms/ L) total number per year with high rank of occurrence. The rare occurrence of species of Bacillariophyta was *Nitzschia Palea* (2×10^3 organisms/ L) followed by *Stephanodiscus asteraea*, *Stephanodiscus hantzschii, Diatoma elongatum* and *Synedra vaucheriae* with (5×10^3 organisms/ L) and *Fragillaria crotonensis* with (9×10^3 organisms/ L) total number per year.

Chlorophyta

Members of Chlorophyta attained the maximum accumulation (2.7×10^4 organisms/ L) in February followed by October with total count (1.9×10^4 organisms /L). August showed no occurrence, April and June showed moderate occurrence of Chlorophyta (1.6×10^4 organisms/ L).The most common species of Chlorophyta was *Tetraedron minimum* with (2.9×10^4 organisms/ L) total number per year with moderate rank of occurrence. Followed by, *Kirchneriella lunaris* and *Scenedesmus armatus* with (1.5×10^4 organisms/ L) total number per year with rare and moderate rank of occurrence, respectively. The rare occurrence of species of Chlorophyta was *Staurastrum polymorphum* with (3×10^3 organisms/ L) total number per year.

Cyanophyta

The maximum accumulation of Cyanophyta was (10×10^3 organisms /L) in February followed by April (8×10^3 organisms/ L) with total count. June, August and December show no occurrence. October showed moderate occurrence of cyanophyta with total count (5×10^3organisms/ L). The most common species of Cyanophyta was *Chrococcus limneticus* with (7×10^3 organisms/ L) total number per year with low rank of occurrence. Followed by, *Merismopdia elegans* with (6×10^3 organisms/ L) total number per year with low rank of occurrence. The rare occurrence was *Spirolina meneghiniana*, with (2×10^3organisms/ L) total number per year, followed by *Oscillatoria agardhii* with (3×10^3 organisms/ L) total number per year**.**

Table (6): A list of the recorded phytoplankton i.e algea, their counts, relative density, number of cases of isolation and rank of occurrence in Dalaton raw ground water plant, during the period of study (2019)

Month Algal Groups	Feb	April	Jun	Aug	Oct	Dec	Total no. per year	Relative density of total (%)	No. of cases of isolation	Rank of occurrence
Bacillariophyta										
Cyclotella comta	60	50	20	14	18	15	177	29.74	6	H
Cyclotella kutzingiana	30	50	35	5	15	20	155	26.05	6	H
Stephanodiscus asteraea	5	0	0	0	0	0	5	0.84	1	R
Stephanodiscus hantzschii	0	5	0	0	0	0	5	0.84	1	R
Diatoma elongatum	0	0	0	0	0	5	5	0.84	1	R
Synedra ulna	5	3	0	4	2	0	14	2.35	4	M
Synedra vaucheriae	5	0	0	0	0	0	5	0.84	1	R
Fragillaria capucina	10	12	0	3	3	0	28	4.71	4	M
Fragillaria crotonensis	5	0	0	0	0	4	9	1.51	1	R
Nitzschia Palea	2	0	0	0	0	0	2	0.34	1	R
Nitzschia amphibia	4	8	0	0	0	4	16	2.69	3	M
Nitzschia angustata	0	0	0	0	20	0	20	3.36	1	R
Melosira granulata	25	10	8	2	0	0	45	7.56	4	M
Chlorophyta										
Scenedesmus armatus	5	5	0	0	0	5	15	2.52	3	M
Staurastrum polymorphu	0	0	0	0	0	0	0	0.5	1	R
Botryococcus braunii	0	0	8	0	0	0	8	1.34	1	R
Chlorella vulgaris	4	6	0	0	0	0	10	1.68	2	L

Tetraedron minimum	18	5	0	0	4	2	29	4.87	4	M
Kirchneriella lunaris	0	0	0	0	15	0	15	2.52	1	R
Nephrocytium Agradhian	0	0	6	0	0	0	6	1.01	1	R
Cyanophyta (b.g)										
Merismopedia elegans	2	4	0	0	0	0	6	1.01	2	L
Chrococcus turgidus	5	0	0	0	0	0	5	0.84	1	R
Chrococcus limneticus	3	4	0	0	0	0	7	1.18	2	L
Spirulina meneghinian	0	0	0	0	2	0	2	0.34	1	R
Oscillatoria agardhii	0	0	0	0	3	0	3	0.5	1	R
Total No. of individuals	188	162	77	28	82	58	595			

N.B: Filamentous and colonial organisms were counted as one organism

Total counts × 10^3= organisms / liter

Rank of occurrence: - High occurrence (from 5 to 6 cases of isolation) Low occurrence (2 cases of isolation)
Moderate occurrence (from 3 to 4 cases of isolation) Rare occurrence (one case of isolation)

Figure (6): The total No. of algal groups of Nile water at Dalton raw ground water plant, during the period of investigation

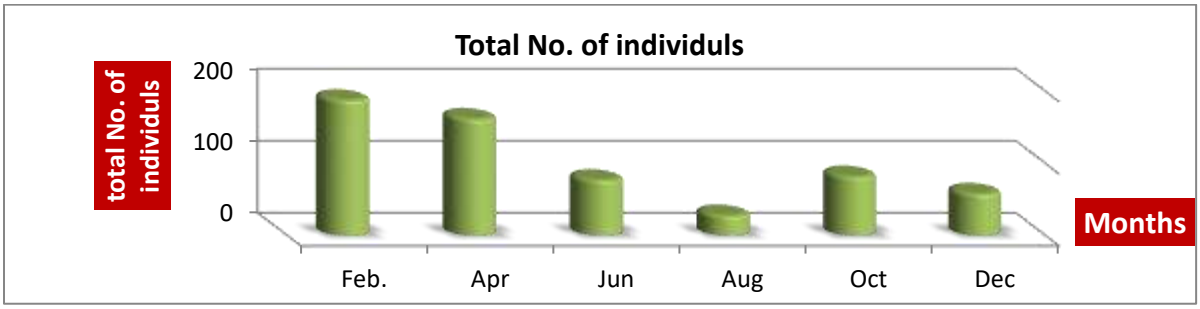

Table (7): Percentage distribution of the phytoplankton groups of raw water at Dalaton ground water plant, during the period of investigation (2019)

Algal groups		Feb	Apr	Jun	Aug	Oct	Dec	Annual average
Bacillariophyta	Species No.	10	7	3	5	5	5	5.8
	% of total	62.5	58.33	60	100	55.56	62.5	66.5
	Individual No.	151	138	63	28	58	48	81.0
	% of total	40.58	85.18	81.81	100	70.73	82.75	76.8
Chlorophyta	Species No.	3	3	2	0	2	3	2.2
	% of total	18.75	25	40	0	22.22	37.5	23.9
	Individual No.	27	16	14	0	19	10	14.3
	% of total	14.36	9.87	18.18	0	23.17	17.24	13.8
Cyanophyta	Species No.	3	2	0	0	2	0	1.2
	% of total	18.75	16.66	0	0	22.22	0	9.6
	Individual No.	10	8	0	0	5	0	3.8
	% of total	5.31	4.93	0	0	6.09	0	2.7

Total counts × 10^3 = organisms / liter

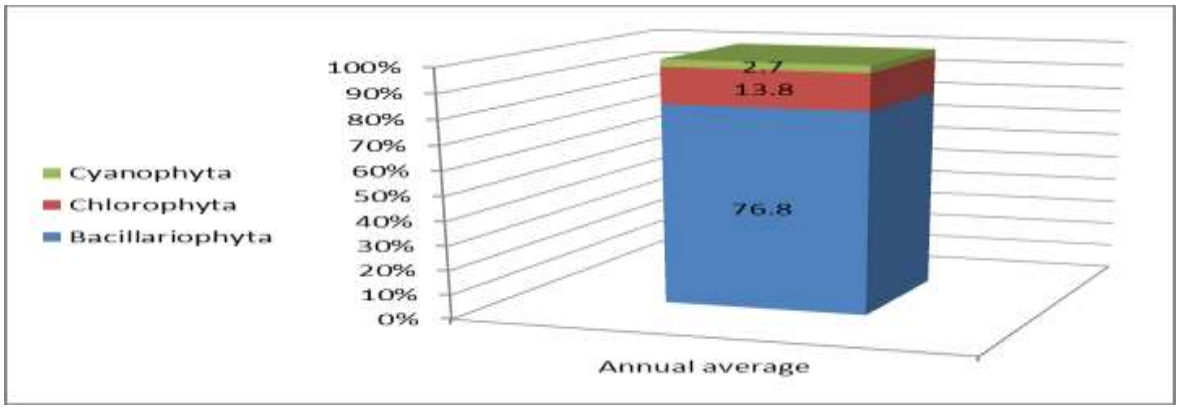

Figure (7): The annual average of algal groups of raw water at Dalton ground water plant, during the period of study

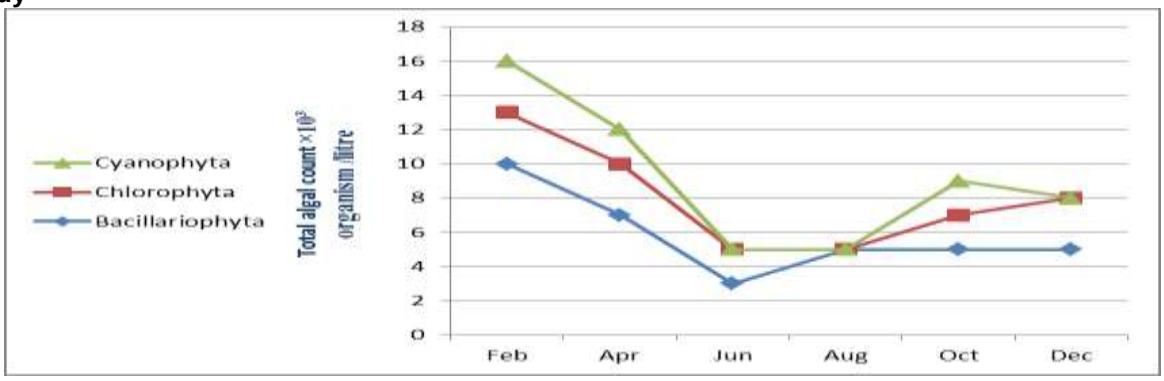

Figure (7a): Species number of algal groups of raw water at Dalton ground water plant, during the period of study

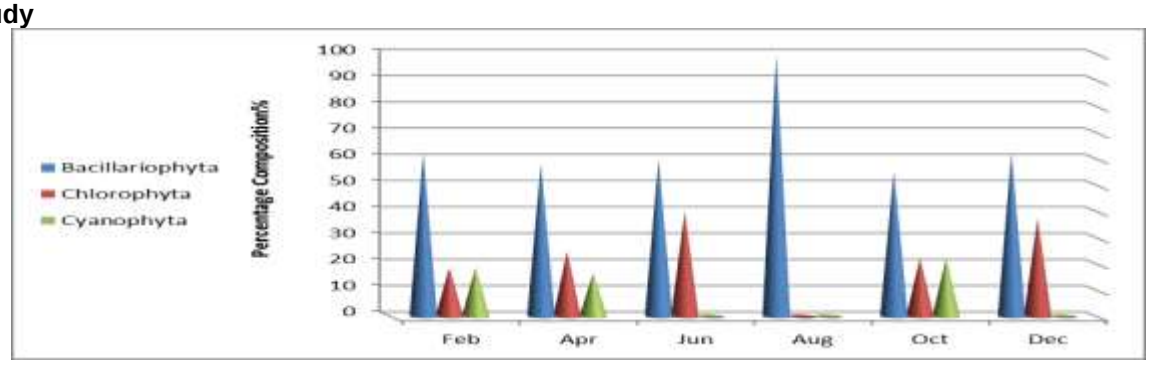

Figure (7b): Percent of total species number of algal groups of raw water at Dalton ground water plant, during the period of study

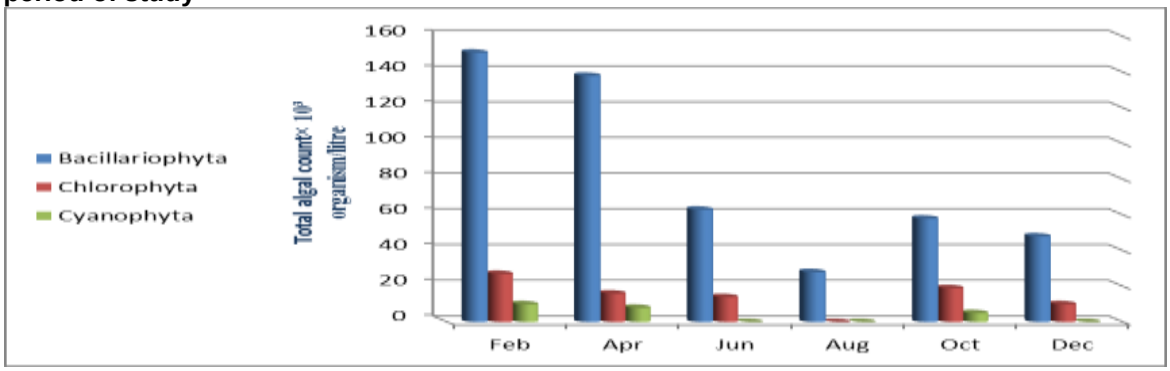

Figure (7c): Individual number of algal groups of raw water at Dalton ground water plant, during the period of study

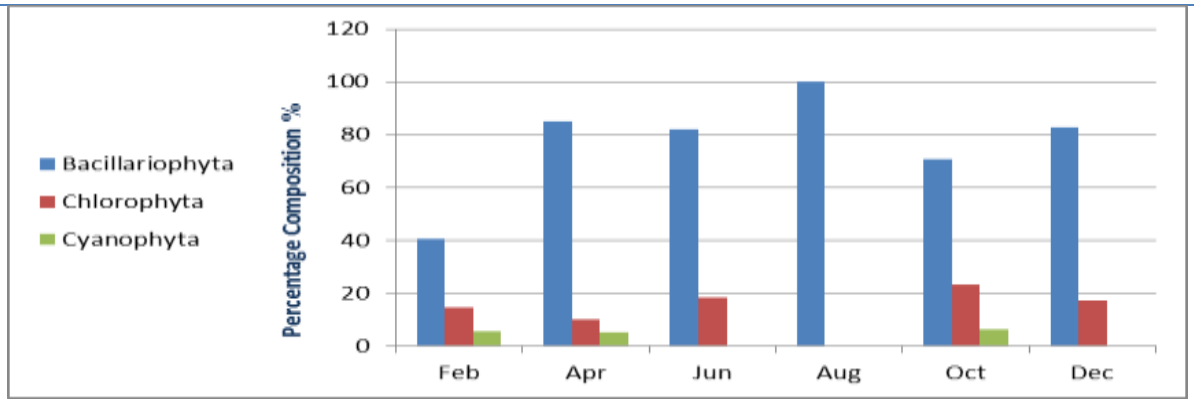

Figure (7d): Percent of total individual number of algal groups of raw water at Dalton ground water plant, during the period of study

Treated water of Dalaton ground water plant

As illustrated in table (8) and represented in figure (8), the total number of phytoplankton populations throughout the period of study per year in Dalton water plant was (91× 10^3 organisms /L). The highest yield was (26× 10^3 organisms /L) in February followed by April and October with yield of (23, 13) ×10^3organisms /L, respectively. On the other hand, the minimum yield was (8× 10^3 organisms /L) in June. December and August showed moderate values (12, 9) ×10^3 organisms /L. As illustrated in table (9) and represented in figure (9), the phytoplankton populations encountered in Dalaton water plant are included in the divisions of Bacillariophyta, Chlorophyta and Cyanophyta. Bacillariophyta dominated the whole populations, as it accounted for 72.9 % of total annual crop with annual average of species number 3.3×10^3 organisms/ L. Chlorophyta ranked as the 2nd division with 25.7 % of total annual crop with annual average of species number 1.0×10^3 organisms/ L, and then followed by Cyanophyta with 1.4 % of total annual crop with annual average of species number 0.3×10^3 organisms/ L. The range, average and seasonal variation of the recorded groups are represented in figures 9(a, b, c and d) and can be summarized as the following:-

Bacillariophyta

Bacillariophyta attained the maximum accumulation (25 × 10^3 organisms /L) in February followed by April with total count (20× 10^3 organisms/ L). The minimum occurrence was (4 × 10^3 organisms/ L) in December followed by June and October (6× 10^3 organisms/ l). August showed moderate occurrence of Bacillariophyta 9 × 10^3 organisms/ L. The most common species of Bacillariophyta was *Cyclotella Comta* with (32 × 10^3 organisms/ L) total number per year with high rank of occurrence. Followed by, *Cyclotella kutzingiana* with (23 × 10^3 organisms/ L) total number per year with high rank of occurrence. The rare occurrence of species of Bacillariophyta was *Fragillaria capucina* (1 × 10^3 organisms/ L) followed by *Synedra unia*, with and *Melosira granulate* with (2 × 10^3 organisms/ L) total number per year.

Chlorophyta

Members of Chlorophyta attained the maximum accumulation (8 × 10^3 organisms/ L) in December followed by October with total count (7 × 10^3 organisms /L). August and February showed no occurrence, April and June showed moderate occurrence of Chlorophyta (2× 10^3 organisms/ L). The most common species of Chlorophyta was *Tetraedron minimum with* (6 × 10^3 organisms/ L) total number per year with low rank of occurrence. Followed by, *Chlorella vulgaris* with (5 × 10^3 organisms/ L) total number per year with rare rank of occurrence. The rare occurrence of species of Chlorophyta was *Scenedesmus armatus* and *Kirchneriella Obesa* with (2 × 10^3 organisms/ L) total number per year.

3- Cyanophyta

The maximum accumulation of Cyanophyta was (1 × 10^3 organisms /L) in February and April (8× 10^3 organisms/ L) with total count. June, August, October and December show no occurrence. There is only one species of Cyanophyta that was detected *Merismopdia elegans* with (2 × 10^3 organisms/ L) total number per year with low rank of occurrence.

Table (8): A list of the recorded phytoplankton, their counts, relative density, number of cases of isolation and rank of occurrence in Dalaton treated ground water plant, during the period of investigation (Feb – Dec 2019).

Month Algal Groups	Feb	Apr	Jun	Aug	Oct	Dec	Total no. per year	Relative density of total (%)	No. of cases of isolation	Rank of occurrence
Bacillariophyta										
Cyclotella comta	15	8	2	4	2	1	32	33.33	6	H
Cyclotella kutzingiana	6	8	4	1	2	2	23	23.95	6	H
Synedra ulna	0	0	0	0	2	0	2	2.08	1	R
Fragillaria capucina	0	0	0	1	0	0	1	1.04	1	R
Nitzschia aclcularis	2	0	0	1	0	0	3	3.13	2	L
Nitzschia amphibia	2	4	0	0	0	1	7	7.29	3	M
Melosira granulata	0	0	0	2	0	0	2	2.08	1	R
Chlorophyta										
Scenedesmus armatus	0	2	0	0	0	0	2	2.08	1	R
Staurastrum polymorphum	0	0	0	0	0	4	4	4.16	1	R
Chlorella vulgaris	0	0	0	0	5	0	5	5.21	1	R
Tetraedron minimum	0	0	0	0	2	4	6	6.59	2	L
Kirchneriella Obesa	0	0	2	0	0	0	2	2.08	2	L
Cyanophyta (b.g)										
Merismopedia elegans	1	1	0	0	0	0	2	2.08	3	M
Total No. of individuals	**26**	**23**	**8**	**9**	**13**	**12**	**91**			

N.B: Filamentous and colonial organisms were counted as one organism **Total counts × 10^3= organisms / liter**
Rank of occurrence: - High occurrence (from 5 to 6 cases of isolation) **Low occurrence** (2 cases of isolation)
Moderate occurrence (from 3 to 4 cases of isolation) **Rare occurrence** (one case of isolation)

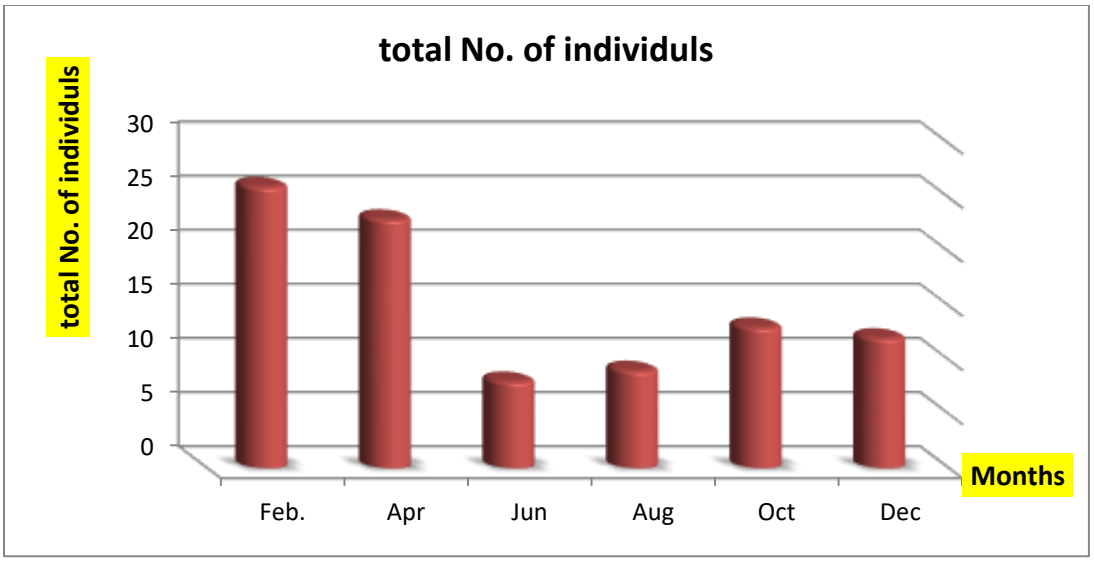

Figure (8): The total No. of algal groups at Dalaton treated ground water plant, during the period of study

Table (9): Percentage distribution of the phytoplankton groups of treated water at Dalaton ground water plant, during the period of investigation (2019)

Algal groups		Feb	Apr	Jun	Aug	Oct	Dec	Annual average
Bacillariophyta	**Species No.**	4	3	2	5	3	3	3.3
	% of total	80	60	66.66	100	60	60	71.1
	Individual No.	25	20	6	9	6	4	11.7
	% of total	96.15	86.95	75	100	46.15	33.33	72.9
Chlorophyta	**Species No.**	0	1	1	0	2	2	1.0
	% of total	0	20	33.33	0	40	40	22.2
	Individual No.	0	2	2	0	7	8	3.2
	% of total	0	8.69	25	0	53.84	66.66	25.7
Cyanophyta	**Species No.**	1	1	0	0	0	0	0.3
	% of total	20	20	0	0	0	0	6.7
	Individual No.	1	1	0	0	0	0	0.3
	% of total	3.84	4.34	0	0	0	0	1.4

Total counts × 10^3= organisms / liter

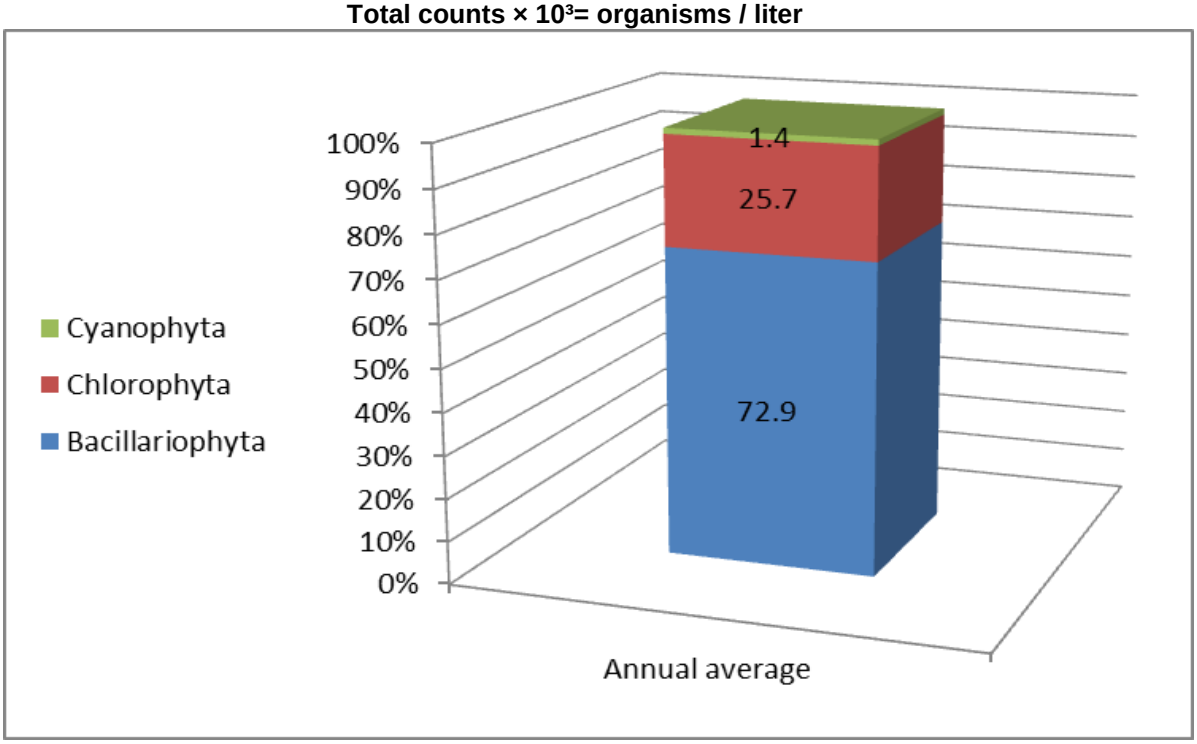

Figure (9): The annual average of algal groups of treated water at Dalaton ground water plant, during the period of investigation

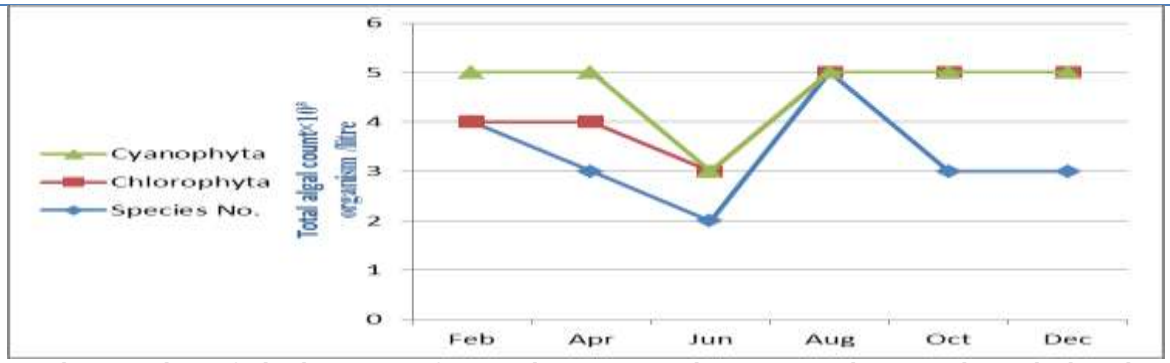

Figure (9a): Species number of algal groups of treated water at Dalaton ground water plant, during the period of study

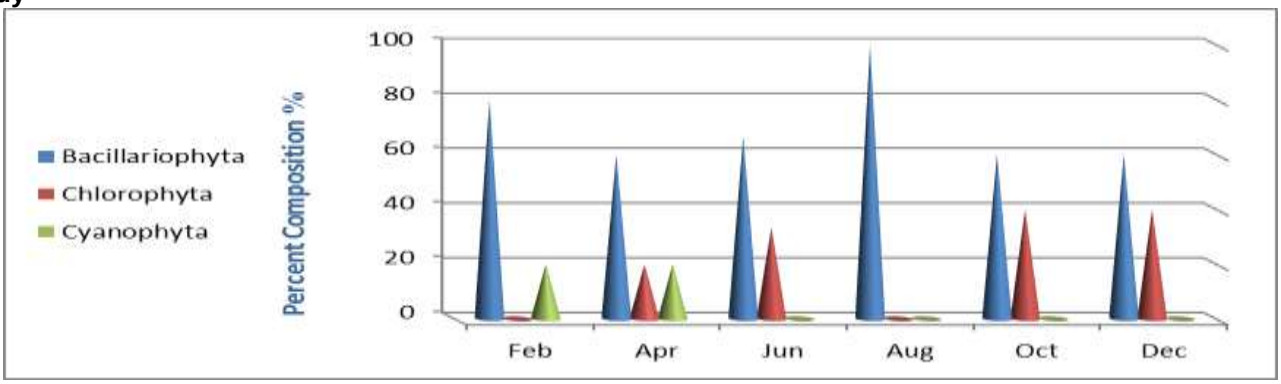

Figure (9b): Percent of total species number of algal groups of treated water at Dalaton ground water plant, during the period of study

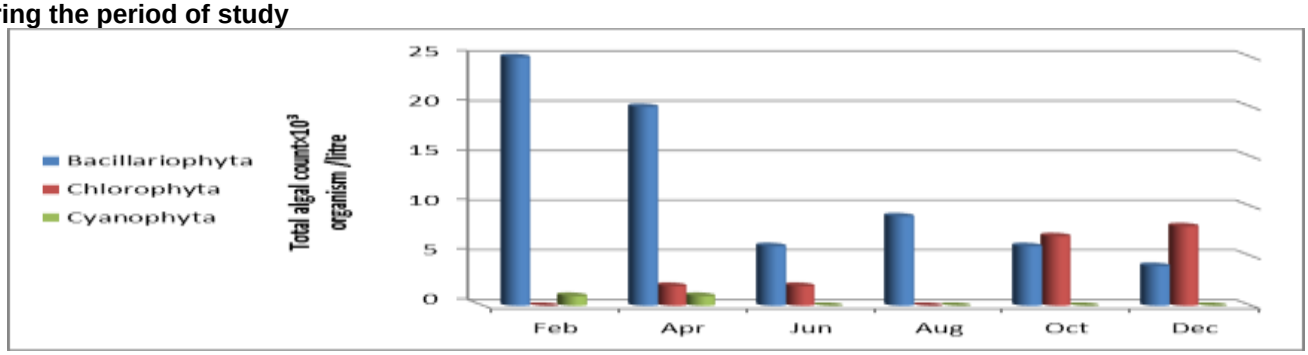

Figure (9c): Individual number of algal groups of treated water at Dalaton ground water plant, during the period of study

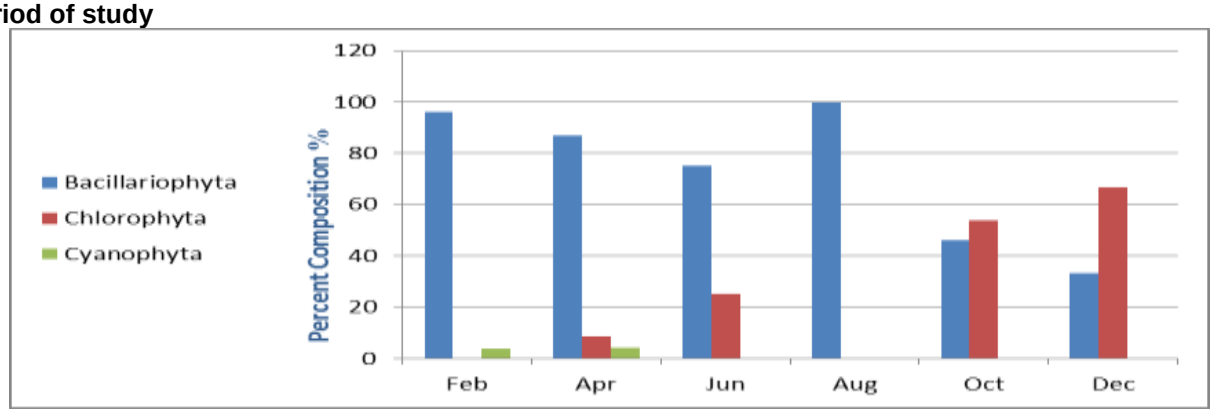

Figure (9d): Percent of total Individual number of algal groups of treated water at Dalaton ground water plant, during the period of study

DISCUSSION

It is necessary for the human population to have potable water with high quality. For this purpose, this investigation was carried out to compare between two types of underground water treatment, to conclude which method would be considered better than the other. To compare the treatments understudy, raw water represents the source of water, and studying its physicochemical properties is important to show the efficiency of each treatment plant. River Bank Filtration is the infiltration of surface water, mainly from a river system into a groundwater system induced by water abstraction near to the surface water as a river bank. As the water flows through the soil, it is filtered and as a result its quality is improved **(Huelshoff *et al.,* 2009)**. Bank Filtration was used for over 100 years in Europe and is now gaining interest and application globally as an effective process for reducing organic and particulate loads to drinking water treatment systems **(Schmidt *et al.,* 2003).** From the results of this study surface water (river bank filtration) was better than ground water in their physicochemical parameters, as it had lower total dissolved salts, iron, manganese, calcium ions, magnesium ions, phosphates and chlorides than ground water. Also total hardness and alkalinity of surface water are less than ground water. Ground water had fewer total bacterial number than surface water but after disinfection with chlorine, all both of them showed negative results. These results agreed with **(Hazaa *et al.,* 2015; Hisham *et al., 2*015; Shaaban *et al.,* 2016**; **Galal *et al.,* 2017 and Yanxia Zhao *et al.,* 2021).** Measuring of certain physico-chemical parameters of water is very important to investigate both water quality and ecological variations of the water body **(WHO, 1996).** Temperature acts as a very significant factor influencing various activities of the microorganisms **(Galal *et al.,* 2011 and Gopalkrushna, 2011).** In the present study, water temperature ranged between 19.0 ºC to 30.1 ºC during the studying period from February to December 2019. Turbidity is daily monitoring parameters in raw water treatment that affects other water characters such as health, physical and disinfection aspects **(Mazloomi *et al.,* 2009).** In the present work, turbidity reached its maximum values in raw water samples Dalaton ground water plant in Summer and Autumn, this agreed with **(NHDES, 2008)** who pointed out that water temperature rose when turbidity of water rose and vice versa. Turbidity in treated samples of in the Dalaton ground water plant decreased after the treatment as (river bank filtration) systems are known to remove turbidity, microbes and chemicals present in surface water and the removal efficiency is a function of well location, pumping rate and source water quality. A fraction of dissolved organic carbon is also removed which helps in reducing the formation potential of disinfection byproducts during chlorination of the filtrate from river bank filtration systems. Total dissolved solids (TDS) comprise inorganic salts and low amounts of organic matter that are dissolved in water. Concentrations of TDS in water vary according to different mineral solubility in different geological regions **(Rainwater and Thatcher, 1960).** In this study the maximum values of TDS achieved in summer in raw water of Meet khaqan ground water plant. Simultaneously, TDS values showed high positive correlation with the electrical conductivity which is confirmed with data obtained by **(Galal *et al.,* 2014).** Alkalinity is the sum of total of components in the water that tend to elevate the pH of the water above of about 4.5. It considered as a means of controlling water and wastewater treatment process, and interpretation of water quality. The seasonal average of bicarbonate values in raw water and treated water samples of Meet khaqan ground water plant increased in summer season. Iron content in Dalaton ground water plant was ranged from 0.01 to 0.16 ppm the while in Meet Khaqan ground water plant ranged from 0.24 to 0.86 ppm. The soluble iron content of surface waters (bank river filtration) rarely exceeds 1 mg /l, while ground waters often contain higher concentration **(WHO, 2008).** The rang of manganese content in raw water and treated water samples of Dalaton ground water plant was ranged from0.01 to 0.16 ppm while for Meet Khaqan ranged from 0.21 to 1.2 ppm this agreed with **(ATSDR, 2000).** In raw water samples of Dalaton ground water plant, the presence of total coliform and fecal coliform indicates blooded animal, which is in concomitant with **(An *et al*., 2002 and Gabrielle *et al.,* 2022).** The seasonal variations showed that the high counts of bacterial indicators detected in the warm seasons (summer and spring) which might be attributed to temperature **(Isobe *et al.,* 2004)** while in Meet Khaqan high counts of bacteria was in (summer and autumn). In the treated water samples, the absence of total and fecal coliform may be attributed to effectiveness of disinfection process **(Goshu, *et al.,* 2021).** These results indicate the safety of treated water owing to the **(WHO, 1993)** which stated that potable water must be free of total and fecal coliforms. Phytoplankton abundance is controlled by physicochemical conditions, water level fluctuation, sunlight and nutrient supply **(Hussian *et al.,* 2015 and Mohamed *et al.,* 2020).** Meet Khaqan ground water plant didn't have any fresh water algea while Dalaton ground water plant showed Algal distribution that was affected by temperature as the highest numbers were indicated in warmer seasons, so the highest algal count was recorded in autumn and spring while the lowest counts recorded during the summer. This agreed with **(Allam and El-Gemaizy, 2015; Hussian *et al.,* 2015; Khairy *et al.,* 2015).** The results of this study showed various phytoplankton structures belonging to three groups, namely, Bacillariophyta, Chlorophyta and Cyanophyta**.** Bacillariophyta represent the most abundant group and Chlorophyta ranked as the 2nd group in their occurrence during the period of investigation. Cyanophyta were present during the period of investigation with low species number and ranked as the 3rd group in their occurrence. These results were agreed with **(Shehata *et al.,* 2008;**

Allam and El-Gemaizy, 2015; Dango *et al.,* 2015; Khairy *et al.,* 2015; Onyema, 2017). For raw water of Dalaton bank river filtration Bacillariophyta dominated the whole populations, as it accounted for 76.8 % of total annual crop with annual average of species number 5.8×10³ organisms/ L. Chlorophyta ranked as the 2nd division with 13.8 % of total annual crop with annual average of species number 2.2×10³ organisms/ L, and then followed by Cyanophyta with 2.7 % of total annual crop with annual average of species number 1.7×10³ organisms/ L. The most common Bacillariophyta species was *Cyclotella comta* with (177 × 10³ organism \l) per year with high rank of occurrence and these results agreed with **(Morsi, 2012; Allam and El-Gemaizy, 2015; Dango *et al.,* 2015; Hussian *et al.,* 2015; Khairy *et al.,* 2015 and Onyema, 2017)**. Chlorophyta was ranked as the 2nd division with in both water plants. The most common Chlorophyta species in Dalton was *Tetraedron minimum* with (29× 10³ organism \l) per year. The presence of high density of Cyanophyta indicates high pollution load and nutrient rich condition **(Muhammad *et al.,* 2005; Tas and Gonulol, 2007 and Sharma *et al., 2*016).** Cyanophyta was ranked as the 3rd group. Their maximum accumulation was (10 × 10³ organism \l) in February. The most common Cyanophyta species was *Chrococcus limneticus* with (7 × 10³ organism \l) per year. Treated water of Dalaton bank river filtration the total number of phytoplankton populations throughout the period of study per year in Dalaton water plant was (91× 10³ organisms /L). The highest yield was (26× 10³ organisms /L) in February followed by April and October with yield of (23, 13) ×10³organisms /L, respectively. Bacillariophyta dominated the whole populations, as it accounted for 72.9 % of total annual crop with annual average of species number 3.3×10³ organisms/ L. Chlorophyta ranked as the 2nd division with 25.7 % of total annual crop with annual average of species number 1.0×10³ organisms/ L, and then followed by Cyanophyta with 1.4 % of total annual crop with annual average of species number 0.3×10³ organisms/ L.

CONCLUSION

Surface water (river bank filtration) represented by Dalaton water plant was more effective method to obtain better potable water than traditional ground water represented by Meet Khaqan water plant in their physicochemical parameters, as it had fewer total dissolved salts, iron, manganese, calcium ions, magnesium ions, phosphates and chlorides than ground water. Also total hardness and alkalinity of surface water are less than ground water. The soluble iron content of surface waters (bank river filtration) rarely exceeds 1 mg /l, while ground waters often contain higher concentration Ground water had fewer total bacterial number than surface water but after disinfection with chlorine. Meet Khaqan ground water plant didn't have any fresh water algea while Dalaton ground water plant showed Algal distribution.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

MTS and HHM conceived and designed the structure of the article. MTS, SAG, and HHM performed the literature search and the data analysis. MTS, SAG, and HHM wrote the first draft of the manuscript. MTS and HHM reviewed the manuscript. SAG carried out the experiments.

All authors read and approved the final version of the manuscript

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