

Pollutants Detection in Water Resources at El Saff Area and Their Impact on Human Health, Giza Governorate, Egypt

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ABSTRACT

The main objective of the present work is the detection of pollutants in water resources (surface water and groundwater) and their impact on human health at El Saff area which occupies the southern position of Giza governorate. Drinking and agriculture in this area depend mainly on the water of Nile River and two main canals namely El Khashab and El Hager canals. Such canals are subjected to pollution from different sources. The shallow groundwater tapped from the near surface quaternary deposits is also subjected to pollution. The so-called El Saff wastewater canal represents one of the main sources of pollution for the water resources in the study area. This canal runs longitudinally for about 50km along the foot slopes of the eastern Eocene escarpment. To achieve the aim of the present study, thirty five surface water and groundwater samples are collected during August (2011) and chemically analyzed for detection of inorganic, biological and bacteriological pollutants. The results indicated that all the detected pollutants are considered very serious to people's health. The most important pollution problem sources include the wastewater produced from the industrial complex at Helwan area in addition to the wastewater discharged into the Nile River and its canals. On the other hand, the excessive seepage of drainage water rich in fertilizers and pesticides causes pollution for groundwater.

Key words: El Saff area (Egypt), water pollution, inorganic pollutants, biological pollutants, bacteriological pollutants.

Introduction

Water pollution problems have led to serious ecological and environmental problems. Contamination of water is a serious environmental problem as it adversely affects the human health and the biodiversity in the aquatic ecosystem.

Rivers worldwide serve as the recipients of great quantities of waste discharged by agricultural and domestic activities. Agriculture seems to be the most considerable source of pollution due to flow from fertilized land.

The Nile River, which represents more than 90% of the Nile basin's water resources, is the traditional receptor of waste and drainage waters generated by different activities (Abu-Shady *et al.*, 1996 and El Gohary 1994).

The main threat to drinking water resources is constant input of pollutant loads from roads, roofs, sewers, industry and agricultural areas. Thus groundwater quality needs to be maintained at a sufficiently high standard to minimize treatment requirements, which in turn is the result of a well-established and enforced protection policy (Goran *et al.*, 2009).

The protection of the water resources and treatment of water pollution are urgent matters to permit ecologically sensitive construction and sustainable socioeconomic development in the whole catchments. To do so, it is first necessary to understand the mechanisms responsible for water pollution and the severity of the problem. This knowledge will allow managers to develop a more reasonable policy for waste management and the prevention of water pollution based on joint efforts by local governments (Jinzu *et al.*, 2009).

El Saff area extends along the eastern side of the Nile River between latitudes 29° 30' - 29° 45' N and longitudes 31° 15' - 31° 25' E. It is bounded by Helwan area to the North, Atfih area to the South, El Saff wastewater canal to the East and Nile River to the West (Fig.1).

Then, its location is just to the south of Helwan area which includes many factories for iron, steel and cements production. These factories constitute sources for pollution of water resources in the study area besides El Saff wastewater canal and polluted agricultural drainage water.

The surface water system in the study area comprises Nile River, El Khashab and El Hagar canals. The groundwater, on the other hand, is represented by the shallow quaternary aquifer.

The major threat for the water resources in El Saff area is comes from the polluted sewage water and drainage water. This situation can be explained on the basis of the uncontrolled disposal of waste as well as

improper disposal of toxic waste from agricultural and other human activities. Other sources of pollution in El Saff area are the abuse of fertilizers and pesticides as well as the direct discharge of untreated municipal water into the river.

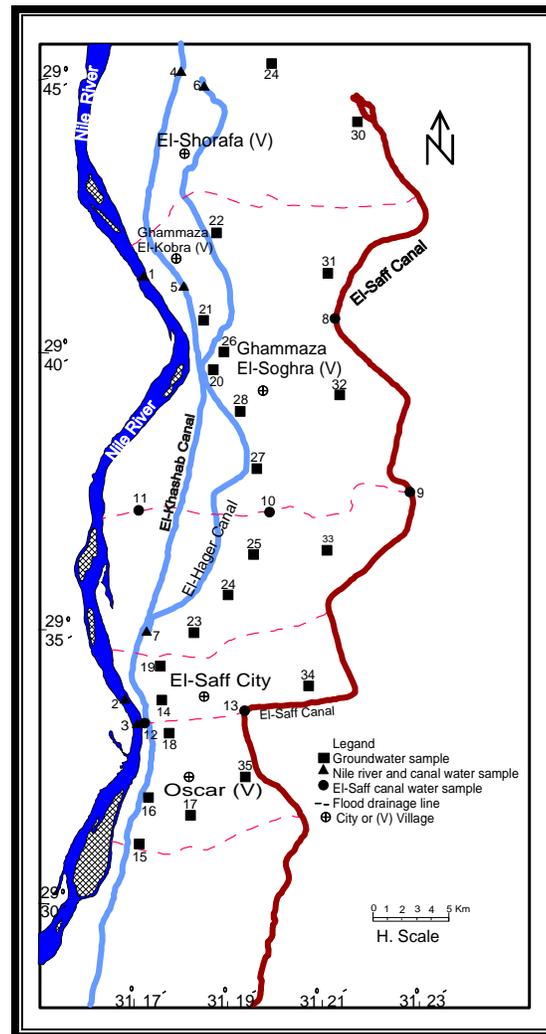


Fig. 1: location map and water samples sites of the study area

Noteworthy, one of the most important factors of water pollution is the microbial contamination; especially with pathogenic microorganisms. Enteric pathogens are typically responsible for waterborne diseases (Karaboze *et al.*, 2003 and Shawky *et al.*, 2007).

Pathogens are a serious concern for managers of water resources, because excessive amounts of faecal bacteria in sewage and urban run-off have been known to indicate risk of pathogen-induced illnesses in humans (Fleisher *et al.*, 1998). Several species of gram-negative bacteria present in municipal wastewater are pathogenic. This pathogenicity is usually associated with certain components of the cell walls, in particular the lipopolysaccharide, also known as LPS or endotoxin; layer (Baron, 1996). Thus, identification of these pathogenic agents in water resources is beneficial for controlling and prevention planning of the infectious diseases. The Nile, unfortunately, receives heavy loads of industrial, agricultural and domestic wastes. Drinking water must meet specific criteria and standards to ensure that water supplied to the public is safe and free from pathogenic microorganisms as well as hazardous compounds (WHO report, 1993).

For a long time, pollution problems are ignored and their effect on the environment were not given due consideration. Consequently, pronounced efforts are needed to control such pollution.

The objectives of this study are;

- 1- To give an overall picture of the pollutants and their sources.

- 2- Pollution loads and water quality determination.
- 3- The impacts of pollutants on the human health.

Materials And Methods

2.1. Water sampling:

Field trip took place within Aug.2011, during which surface water and groundwater samples were manually and aseptically collected from the study area. The sampling sites used to provide the data reported in this paper appear in Fig.(1). The present research is based on the results of thirty five (35) collected water samples corresponding to all available water sources included surface water (13 samples) and groundwater (22 wells) in El Saff area were obtained for chemical and biological as well as bacteriological analyses. These water samples were collected from their water points and separated into three aliquots. One of aliquots was acidified with nitric acid (1%) and stored in pre-cleaned polyethylene bottles for the measurements of trace elements and soluble heavy metals. The second aliquot was taken in special container (100ml) for the measurements of biochemical oxygen demands (BOD₅), chemical oxygen demands (COD) and total organic carbon (TOC). Finally, the third aliquot was collected in a special antiseptic container (100ml) for the measurements of microbiological and pathological analyses of water. These water samples were immediately kept in the dark, cooled in an insulated container and transported to the laboratory within 10h. and stored at 4°C until bacteriological analysis was completed within 24h. of collection as specified in standard national and international methods.

2.2. Field measurements:

In situ measurements for water samples were carried out as locations (latitudes and longitudes) using GPS instrument model (Magellan Nave 5000 pro.) together with some physical and chemical characteristics as EC in $\mu\text{S}/\text{cm}$ using Electrical Conductivity meter (Jenway, model 470) and pH using pH meter (Jenway, model 3150).

2.3. Laboratory analyses:

The analyses included the determination of EC using EC meter model Orion (150 A+) and pH using bench-top pH meter (Jenway 3510). The inorganic constituents (B^{3+} , Al^{3+} , Fe^{3+} , Mn^{2+} , Hg^{2+} , Cu^{2+} , Mo^{2+} , Pb^{2+} and Zn^{2+}) were determined using ICAP model (thermo 6500) according to (ASTM, 2002). Also, the concentrations of ammonia (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-) and phosphate (PO_4^{3-}) were determined by colorimetric methods using UV/Visible spectrophotometer (Thermo-Spectronic 300) according to (Fishman and Friedman, 1985). Biochemical oxygen demand (BOD₅) with the five-day incubation method and chemical oxygen demand (COD) using potassium permanganate method were determined also according to (ASTM, 2002). The obtained chemical data were expressed in milligram per liter (mg/l) or part per million (ppm).

The total viable bacterial counts (TVBCs) at 22°C and 37°C were determined using the spread-plate method (APHA, 1995). The number of total and faecal coliforms were determined using the most probable number (MPN) method using MacConkey broth media. The positive tubes were streaked on the Eosin Methylene Blue (EMB) agar plates. Microscopic examination was carried out to ensure gram-negative, non-spore forming rods (APHA, 1995). MPN of faecal streptococci was determined using azide dextrose broth at 37°C for 48hr. Positive tubes were indicated by dense turbidity and confirmed using ethyl violet azide dextrose broth incubated at 37°C for 24hr. (APHA, 1995). The isolation of gram-negative bacteria for groundwater samples in the study area were performed using MacConkey agar supplemented with 0.001g/L crystal violet (Hausler and Koontz, 1970). Several isolates were purified, screened and the suspected similar ones were grouped for the purpose of selection and identification processes.

Isolates from the examined water samples were subjected to identification by biochemical characteristics using API 20E strip system (BioMereux). Each API 20E strip consists of thirty five water points containing dehydrated media. The isolate to be tested was suspended in sterile saline and added to each water sample. The inoculated strip was incubated for 16-24h and the color reactions were noted either positive or negative.

Results and discussion

To achieve the main aim of this research, water pollution will be discussed on the basis of determining inorganic and biological pollutants as well as bacteriological analyses with regard to the recommended levels of contamination (WHO, 2006 and Egyptian Higher Committee for Water, 2007 as well as Rowe and Abdel-Magid, 1995), shown in Tables (1 and 2).

3.1. Inorganic pollutants:

The inorganic pollutants in the water samples of the study area are discussed through the measurements of Al^{3+} , Fe^{3+} , Hg^{2+} , Mn^{2+} , Cu^{2+} , Mo^{2+} , Pb^{2+} and Zn^{2+} as well as B^{3+} , NO_3^- , NO_2^- , NH_4^+ and PO_4^{3-} .

3.1.1. Al^{3+} , Fe^{3+} , Hg^{2+} , Mn^{2+} , Cu^{2+} , Mo^{2+} , Pb^{2+} and Zn^{2+} constituents:

Based on the results of analysis of the inorganic constituents and acceptable contaminant levels (Tables 1 & 2), it is clear that;

1-For Nile River, all water samples are contaminated with Hg^{2+} ion, as they have concentrations (0.0027-0.0074mg/l), above the acceptable limit of contamination. On the other hand, water samples Nos. 1 & 2 have Fe^{3+} ion concentrations (0.3665-0.3999mg/l), higher than the acceptable limit of contamination. Also, sample No.2 has Al^{3+} ion concentration (0.3632mg/l), slightly more than the acceptable limit of contamination. These high concentrations of Hg^{2+} , Fe^{3+} and Al^{3+} ions in the water samples are due to that their locations at the outlets of El Saff wastewater canal which release into Nile River water across the floods runway in the area of study, where El Saff canal is considered as an acceptor for the industrial wastes that coming from the factories existed in Helwan area which is located at north of the study area.

2-For El Khashab and El Hager canals, water samples are contaminated with Fe^{3+} and Hg^{2+} ions, as they have concentrations that ranged from 0.3683 to 1.163mg/l and from 0.007 to 0.1957mg/l, respectively, higher than the acceptable levels of pollution. Water sample No.6 has Mn^{2+} and Pb^{2+} ions concentrations (0.6808 and 0.0366mg/l), respectively, higher than the acceptable levels of pollution. The high concentrations of Fe^{3+} , Hg^{2+} and Mn^{2+} ions are due to that El Khashab and El Hager canals are recharged from Nile River (which is exactly polluted by some of these contaminants as Fe^{3+} and Hg^{2+}) and also these canals received industrial wastes from factories existed in the study area that discharged their wastes in these canals at these localities, while the canals are polluted by Pb^{2+} ions due to the high traffic intensity. In addition, high Fe^{3+} , Hg^{2+} , Mn^{2+} and Pb^{2+} ions concentrations are detected in irrigation canals that can be attributed to the deposition of most of the waste suspended materials in these canals. Consequently, the distribution of these soluble ions in the irrigation water was mainly affected by their occurrence in the liquid wastes discharged into the irrigation canals. The industrial complex at Helwan produces large amounts of liquid wastes (about 115000 m³/day) loaded by about 3.39 tons/day of suspended solids which currently are discharged into El Khashab and El Hager canals as well as the Nile River, and certainly pollute such water (Abdel-Aal *et al.*, 1988).

3-For El Saff wastewater canal, all the collected water samples are contaminated as they have concentrations of Fe^{3+} ion (0.6039 - 18.68mg/l), higher than the acceptable limit of pollution. Also, sample No.(10) has Al^{3+} and Pb^{2+} ions concentrations, 0.8732 and 0.0166mg/l, respectively, higher than the acceptable limits of pollution. For instance, sample No.(8) has Al^{3+} ion concentration (0.3343mg/l), more than the acceptable limit of contamination. This is due to that El Saff wastewater canal acts as an acceptor for discharging large amounts of irrigation drainage water containing impurities of soluble metals from the intensive use of fertilizers and pesticides together with industrial wastes discharge into this canal at south Helwan area.

4-For groundwater, all collected water samples are polluted as they have Hg^{2+} ion concentrations (0.003-0.033mg/l) greater than the acceptable limit of pollution. Also, 22% of the collected groundwater samples are contaminated and exceeded the permissible limit of pollution as they have Fe^{3+} ion concentration ranged from 0.4321 to 1.77mg/l, 14% of the water samples are polluted with Mn^{2+} , where they have Mn^{2+} ion concentrations (0.4028-0.5156mg/l) above the limit of pollution. The higher ions concentrations of Al^{3+} and Zn^{2+} ions (0.337 and 9.84mg/l, respectively) are strictly confined to water samples Nos.29 and 31, respectively. These results confirm that there is a seepage from El Khashab and El Hager canals as well as from El Saff wastewater canal that contains relatively high soluble metals as well as downward infiltration of excess amounts of irrigation water rich in fertilizers and pesticides to the groundwater aquifer. Noteworthy to mention that, the main recharge sources of the Quaternary aquifers are the seepage from Nile water and downward infiltration from the excess irrigation water of cultivated lands as well as the seepage from canals and drains (Yousef, 2007). ElSaff wastewater canal was generally dug in the Pliocene clay sediments and sometimes cutting the foot slope of the eastern limestone plateau. These rocks traversed by many wadi courses. Wadi deposits that fill these courses facilitate the arrival of the canal water not only to the old cultivated lands but also to the Nile course itself. On the other hand, the consequent water level contour map shows that the movement of groundwater takes place essentially from east to west, i.e. from the new reclaimed area around El Saff canal (+71m) to the old cultivated lands (+26m to +24m) near the Nile River (+23m) since the latter acts as a discharging area for the former (Elsheikh, 2008). Also, the results of the geoelectrical survey in Ghamaza area reveal that the groundwater exists at shallow depths ranging from 7.5 to 10.8m and the sedimentary section above the water table consists of gravel and sand which permits seepage and filtration from the disposal site to the groundwater (Mahmoud *et al.*, 2012). This does not exclude the contribution of aquifer matrix interaction, which leads to some release of

more soluble heavy metals. Therefore, all groundwater samples are seriously polluted by soluble inorganic pollutants especially near El Saff wastewater canal and agricultural liquid wastes.

5-All water samples (surface water and groundwater) collected from the study area have Mo^{2+} and Cu^{2+} ions concentrations below the acceptable limits of contamination.

6-All water sources in the concerned area are suitable for irrigation except El Saff wastewater canal as it has iron and manganese ions concentrations more than the permissible limits for irrigation (5 and 0.2mg/l, respectively), (Rowe and Abdel-Magid, 1995).

Table 1: Concentrations of the inorganic constituents in the water resources samples within the study area (mg/l).

Sample No.	Al^{3+}	Fe^{3+}	Hg^{2+}	Mn^{2+}	Cu^{2+}	Mo^{2+}	Pb^{2+}	Zn^{2+}
Surface water								
Nile River water								
1	0.0562	0.3665	0.0074	0.0579	0.0017	0.00029	0.0009	0.009
2	0.3632	0.3999	0.0027	0.0733	0.0017	0.00029	0.0009	0.0021
3	0.0735	0.0798	0.0074	0.0478	0.00029	0.00029	0.0009	0.009
El Khashab and El Hager canals water								
4	0.188	0.5564	0.1957	0.2517	0.0006	0.00029	0.0043	0.0116
5	0.061	1.163	0.0056	0.149	0.00029	0.00029	0.0044	0.0197
6	0.2088	0.3683	0.0422	0.6808	0.0019	0.00029	0.0366	0.038
7	0.2085	0.2667	0.007	0.0881	0.00029	0.00029	0.0009	0.009
El Saff wastewater canal								
8	0.3343	18.68	0.0186	0.2827	0.0311	0.0046	0.0063	0.2731
9	0.1761	3.753	0.0107	0.2595	0.016	0.0023	0.0034	0.1375
10	0.8732	6.324	0.0102	0.2467	0.0535	0.0018	0.0166	0.5224
11	0.1114	0.6039	0.0072	0.2366	0.00029	0.00029	0.0021	0.0061
12	0.1852	2.951	0.0073	0.3507	0.0032	0.00029	0.0035	0.0194
13	0.1483	0.6664	0.004	0.1713	0.0044	0.00029	0.0026	0.011
Groundwater								
14	0.0049	0.0029	0.007	0.4028	0.0013	0.00029	0.0021	0.0564
15	0.0049	0.0029	0.0073	0.0009	0.001	0.00029	0.0028	0.009
16	0.0235	1.77	0.0093	0.0164	0.0048	0.00029	0.0035	0.5826
17	0.0056	0.0207	0.0063	0.0029	0.00029	0.00029	0.0042	0.009
18	0.0061	1.109	0.0076	0.0104	0.00029	0.00029	0.003	2.226
19	0.0177	0.4321	0.0059	0.4257	0.0036	0.00029	0.0045	0.0044
20	0.0216	0.5401	0.0039	0.0078	0.00029	0.00029	0.0043	1.692
21	0.0256	0.2978	0.003	0.5156	0.007	0.00029	0.0049	0.1623
22	0.0052	0.1467	0.0047	0.03884	0.0013	0.0043	0.0022	0.1433
23	0.0275	0.1278	0.0064	0.0227	0.0059	0.00029	0.0037	0.5078
24	0.0056	0.1148	0.0062	0.1366	0.00029	0.0037	0.0024	0.047
25	0.0049	0.0032	0.0076	0.0009	0.00029	0.013	0.0013	0.009
26	0.0049	0.0029	0.0081	0.002	0.00029	0.00029	0.0018	2.105
27	0.0049	0.0029	0.0081	0.0009	0.00029	0.0329	0.0049	0.009
28	0.0049	0.0029	0.0081	0.0009	0.00029	0.0101	0.0041	0.0001
29	0.337	0.0029	0.033	0.0014	0.0004	0.0013	0.0027	0.0505
30	0.0201	0.0029	0.0316	0.0013	0.0011	0.0016	0.0011	0.01
31	0.0103	0.0029	0.0253	0.0644	0.0102	0.0037	0.0078	9.84
32	0.0105	0.0351	0.0112	0.0223	0.00029	0.0004	0.0016	0.009
33	0.0049	0.6271	0.0083	0.0059	0.0024	0.02	0.0015	0.676
34	0.025	0.1012	0.0092	0.001	0.0027	0.0.05	0.0031	0.2258
35	0.0034	0.0068	0.0093	0.0009	0.00029	0.0417	0.0022	0.0325
Permissible levels	0.2	0.3	0.001	0.4	2	0.07	0.01	5

3.I.ii. Boron constituent:

1-For Nile River and, El Khashab and El Hager canals, as shown in table (2), a low concentration of boron in all collected water samples is observed and it ranges between 0.0151 and 0.1809mg/l, i.e., below the acceptable limit of pollution.

2-For El Saff wastewater canal, the majority of collected water samples (67%) has boron concentration ranges from (0.2311 to 0.3288mg/l), below the acceptable limit of pollution. The relatively high concentrations of boron (0.4912 and 0.701mg/l) are detected in samples Nos.11 and 13, respectively, this is due to the discharge of sewage water and industrial wastewater rich in sodium tetra borate (borax) which is widely used as a cleaning aid (Hem, 1989).

3-For groundwater, most of collected water samples (59%) have boron concentrations (0.0203 to 0.3546mg/l), below the acceptable limit of pollution, while the rest of samples (41%) have boron concentrations (0.6211 to 2.634mg/l), i.e., more than the permissible limit of pollution, this is attributed to downward infiltration of excess irrigation water and drainage water rich in fertilizers and pesticides.

3.I.iii. Nitrate constituent:

1-For Nile River and, El Khashab and El Hager canals, all collected water samples have nitrate concentrations range from 1.4 to 25.4mg/l, Table (2), which are below the safe level for drinking water.

2-Concerning El Saff wastewater canal, 83% of the collected water samples have nitrate concentrations range from 7 to 24.4mg/l, considerably high concentration (66mg/l) is detected in sample No.13 (7% of samples), due to the outlets of drainage irrigation water into this canal at this site.

3- All groundwater samples are within the permissible limit of drinking water, as they have concentrations range from 0.6 to 42.2mg/l, (Table 2), below the safe level for drinking water. Noteworthy to mention that the relatively high NO_3^- concentrations of 42.2 and 30.6mg/l that found in the two groundwater samples Nos. 18 and 25, respectively, are considered critical concentrations and may increase by time.

The primary source of nitrates in groundwater is the leaching of nitrate salts into the groundwater supply from agricultural fertilization and the seepage of sewage water. Agricultural practices result in non-point-source pollution of groundwater, and the effect of these practices accumulate over time (Schilling and Wolter, 2001; Liu *et al.*, 2005). In addition to agricultural practices, non-point sources of pollution include nitrogen dissolved in precipitation, irrigation return flows and dry deposition (Almasri and Kaluarachchi, 2004). Point sources of nitrogen such as septic systems have been shown to contribute to nitrate pollution of groundwater.

3.I.iv. Nitrite constituent:

1-The concentrations of NO_2^- ions in the Nile River and, El Khashab and El Hager canals water samples range from 0.015 to 0.135 mg/l, i.e., below the permissible limit of pollution, Table (2). Concerning El Saff wastewater canal samples, all water samples have nitrite concentrations range between 0.21 and 4.84mg/l, higher than the acceptable limit of pollution due to the outlets of drainage irrigation water into this canal.

2-Results show that the majority of groundwater samples (91%) has nitrite concentrations range from 0.004 to 0.054mg/l, i.e., below the permissible limit of pollution. Except 9% of the groundwater samples (Nos. 19, 31) that have nitrite concentrations of 0.675 and 0.315 mg/l, respectively, more than the permissible limit of pollution, this is due to the effect of the wastewater of El Saff canal (seepage from El Saff wastewater canal to groundwater at these localities).

3.I.v. Ammonia constituent:

1-The term ammonia includes the non-ionized (NH_3) and ionized (NH_4^+) species. The concentrations of NH_4^+ ions in the Nile River range from 0.1 to 2.8 mg/l, while for El Khashab and El Hager canals water samples, the concentrations of NH_4^+ range from 0.2 to 4.8 mg/l (Table 2), i.e., the majority of the Nile River and its canals water samples (71%) have ammonia concentrations higher than the permissible limit of pollution, this is due to the drainage of El Saff wastewater canal in the Nile River, El Khashab and El Hager canals at these sites.

2-Concerning El Saff wastewater canal samples, all samples are contaminated as they have ammonia concentrations range from 2.2 to 8.2mg/l, i.e., higher than the acceptable limit of pollution due to the outlets of drainage irrigation water into this canal.

3-The majority of groundwater samples (95%) have ammonia concentrations range from 0.6 to 4.8mg/l, i.e., higher than the permissible limit of pollution. In contrast, the rest of groundwater samples (5%), represented by sample No. 35 has ammonia concentration (0.2mg/l), less than the permissible limit of pollution. The high concentration of ammonia in groundwater is due to the seepage from El Saff wastewater canal at these localities and irrigation return flow rich in ammonium fertilizers as ammonium phosphate $(\text{NH}_4)_3\text{PO}_4$ and ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$. Also, wastewater, animal manure, and refuse dumps may be considered as important sources for elevated ammonium in groundwater (Chen *et al.*, 2006).

3.I.vi. Phosphate constituent:

1-For the Nile River, all water samples have phosphate ions concentration ranges from 0.025 to 0.311mg/l, Table (2), i.e., below the permissible limit of pollution (1mg/l) that stated by Fadiran *et al.*, 2008.

2-In El Khashab and El Hager canals, all water samples have phosphate ions concentration ranges from 0.246 to 1.298mg/l. 50% of the collected samples (samples Nos. 4 and 6) are polluted as they have concentrations more than the permissible limit of pollution (1.185 and 1.298, respectively). The relatively high concentration of phosphate in the canals is attributed to the disposal of wastewater in them at these sites.

3- In El Saff wastewater canal, the phosphate ions concentrations samples range from 0.015 to 1.688mg/l. The relatively high concentration of phosphate is detected at samples Nos. 9 and 10 as they have phosphate

concentrations 0.988 and 1.688mg/l, respectively, due to the outlet of drainage irrigation water into this canal, where the wastewater effluents represent important sources of phosphate.

4- In the groundwater samples, Phosphate ions concentration ranges from 0.008 to 5.287mg/l, the relatively high phosphate concentrations in groundwater samples are detected at samples Nos.18 & 21 as they have concentrations 5.287 and 2.208mg/l, respectively, more than the permissible limit of pollution referred to the seepage from El Saff wastewater canal at these localities and return flow after irrigation.

3. II. Biological pollutants:

Three items are discussed here; the biochemical oxygen demand (BOD₅), chemical oxygen demand (COD) and total organic carbon (TOC).

3.II.i. Biochemical oxygen demand (BOD₅):

1-For the Nile River, all representative water samples of the Nile River are free from BOD₅ concentrations.

2-For El Khashab and El Hager canals, all collected water samples in the study area are unsuitable for drinking purpose, as they have BOD₅ concentrations that range from 12 to 30mg/l, i.e., more than the acceptable limit of pollution, Table (2), this is due to the drainage of both wastewater (houses drain) and the outlets of factories especially for chemical, pulp and food industries into these canals. This is manifested by the previous work of Chhatwal *et al.*, 1993, which stated that manufacturing produces large quantities of BOD₅. The major contributors are the chemical industry (about 44% of the manufacturing BOD₅), the pulp and paper industry (about 27%), and the food processing industries (about 20%).

3-On the other hand, for El Saff wastewater canal, the BOD₅ concentration (6mg/l) was detected in samples Nos. 11 and 13, while the rest samples are free from BOD₅ concentration. This is due to that El Saff wastewater canal acts as an acceptor for discharging of industrial wastes.

4-For the groundwater, most of the groundwater samples (60%) in the study area are suitable for drinking purpose, while the rest of groundwater samples (40%) are contaminated as they have BOD₅ concentrations (8-63mg/l) more than the safe limit for drinking water, table (2). This is due to seepage from El Khashab and El Hager canals, in addition to return flow after irrigation.

3.II.ii. Chemical oxygen demand (COD):

The results of COD determinations obviously do not correspond to the values obtained by BOD₅ determinations, where COD values are higher than that of BOD₅ values, but they may be helpful in comparing conditions in a stream at one time with those at another time (Table 2).

1-Results revealed that the representative samples of the Nile River and, El Khashab and El Hager canals in the study area have high values of COD concentrations (16.8 and 33.6 - 67.2mg/l, respectively), more than the permissible limit of drinking water. These high values are due to drainage of El Saff wastewater canal into the Nile River and, El Khashab and El Hager canals water at these localities, in addition to the outlets of the pulp and paper industry factories where the chemical oxygen demand (COD) resulting from industrial wastewater, especially the residues and wastewater generated by the pulp and paper industry have high COD and BOD₅, high levels of chlorophenols, a strong color, and contain more than 500 different adsorbent organic halide compounds, (Savant *et al.*, 2005).

2-For El Saff wastewater canal, all the collected water samples are contaminated as they have COD concentrations range from 33.6 to 50.4mg/l, more than the permissible limit of pollution. These high values are due to the outlets of the pulp and paper industry factories in this canal.

2-For groundwater samples, the majority of the collected samples (95%) are unsuitable for drinking purpose as they have COD concentrations (12-168mg/l) more than the permissible limit of pollution. The high value for groundwater samples is due to the seepage from El Saff wastewater canal and El khashab and El Hager canals to groundwater, respectively.

3.II.iii. Total organic carbon (TOC):

All surface water and groundwater samples in the study area contain total organic carbon concentrations less than the permissible limit for drinking use (Table 2).

3.III. Bacteriological pollutants:

The bacteriological analyses involved total viable bacterial counts (TVBCs), total coliforms (TC) and estimation of faecal coliforms (FC), faecal streptococci and pathogenic bacteria.

The results of the total number of bacteria are shown in table (3). The total number of bacteria ranged from 2×10^4 to 276×10^4 cfu/ml and from 4×10^4 to 361×10^4 cfu/ml at 22°C and 37°C, respectively.

The most probable number (MPN) of faecal indicators total coliforms (TC), faecal coliform (FC) and faecal streptococci (FS) are shown in table (3).

MPN of TC varied from 10 to 1800/100ml and from 2 to 430/100ml water for FC. The counts of FS fluctuated between 2 and 210/100ml water in El Saff area

The highest bacterial indicators were recorded at El Saff area. This might be explained by the effect of domestic and agricultural wastes discharge from the urbanized surrounding area (Shaaban-Dessouki *et al.*, 1993).

The ratio FC/FS points to the source of faeces whether it is human (> 4) or animal (< 0.7) (Geldreich, 1974), accordingly, the FC/FS ratio was in the range of 0.19-11, which means the mixed origin of faecal pollution.

Table 2: Concentrations of inorganic and biological constituents in the water resources samples within the study area (mg/l).

Sample No.	B ³⁺	NO ₃ ⁻	NO ₂ ⁻	NH ₄ ⁺	PO ₄ ³⁻	BOD ₅	COD	TOC%
Surface water								
Nile River water								
1	0.0182	9	0.015	1.2	0.044	Nil	16.8	0.00167
2	0.0151	9.2	0.022	0.1	0.311	Nil	16.8	0.4975
3	0.0734	9.6	0.042	2.8	0.025	Nil	16.8	Nil
El Khashab and El Hager canals water								
4	0.0978	23.2	0.016	1	1.185	30	33.6	0.00167
5	0.0365	1.4	0.047	1.8	0.356	30	33.6	Nil
6	0.1809	25.4	0.021	4.8	1.298	12	67.2	0.00167
7	0.0175	2.2	0.135	0.2	0.246	12	67.2	Nil
El Saff wastewater canal								
8	0.2517	7	4.28	8	0.442	Nil	33.6	Nil
9	0.2323	17.8	4.84	6.6	0.988	Nil	33.6	Nil
10	0.2311	10	4.12	8.2	1.688	Nil	33.6	0.00167
11	0.4912	22.8	0.051	2.8	0.015	6	50.4	Nil
12	0.3288	24.4	0.302	3.2	0.299	Nil	33.6	Nil
13	0.701	66	0.21	3.4	0.134	6	33.6	Nil
Groundwater								
14	0.0255	0.6	0.006	3.4	0.008	Nil	33.6	Nil
15	0.1264	6.4	0.004	2.4	0.015	Nil	9	Nil
16	0.3248	7.6	0.033	1	0.442	Nil	50.4	Nil
17	0.0987	7.8	0.007	0.8	0.09	Nil	12	Nil
18	0.1992	42.2	0.006	3.6	5.287	3	16.8	Nil
19	0.3241	3.2	0.675	1.6	0.016	Nil	33.6	Nil
20	0.0702	5.4	0.035	3	0.219	Nil	21	Nil
21	0.0497	18	0.037	2.6	2.208	Nil	21	Nil
22	0.0593	1.8	0.021	0.8	0.207	6	16.8	Nil
23	0.6211	7.8	0.014	2.8	0.071	Nil	33.6	Nil
24	0.3454	14	0.026	2.2	0.08	6	67.2	Nil
25	0.6480	30.6	0.014	1.2	0.140	Nil	67.2	Nil
26	0.0203	7.8	0.054	4.8	0.093	6	50.4	Nil
27	0.1678	5.6	0.034	1.4	0.120	8	40.1	Nil
28	0.3546	4.5	0.025	2.5	0.091	10	60.2	Nil
29	1.516	19	0.041	2	0.191	30	35.6	0.00167
30	1.037	3.6	0.006	3.2	0.218	12	33.6	Nil
31	1.252	13.6	0.315	4	0.292	15	50.4	Nil
32	2.242	5.6	0.017	5	0.11	51	168	Nil
33	2.334	11.2	0.019	2.2	0.2	57	150	Nil
34	2.283	17.6	0.012	0.6	0.25	31	50.4	Nil
35	2.634	8.6	0.011	0.2	0.403	63	100.8	Nil
Permissible levels	0.5	45	0.2	0.5	1	6	10	10

On the other hand, (Niewolak, 1998) reported that the data on absolute values of FC: FS may not reflect the source of contamination in Czarna Hancza River, Poland.

According to the guideline criteria for faecal indicator organisms of WHO report (1993) which accept the guide values of the investigated bacteria up to 500/100ml for total coliforms and 100/100ml for both faecal coliforms and faecal streptococci, the survey of the indicator bacteria along El Saff water resources revealed that the Nile River water at this branch is subjected to sewage pollution.

In the present study, the isolates of genus 1 were differentiated and confirmed by API 20E as *E. coli* (Table 4), *E. coli* is the main indicator of faecal pollution, which causes diarrhea, vomiting and fever, this also indicated that all water resources of El Saff are subjected to sewage pollution.

Based on morphological and API 20E biochemical reactions (Table 4), most members of genus 2 are identified as *Pseudomonas fluorescense*.

At present, the genus *Klebsiella* is subdivided into 5 species (Podschn, *et al.*, 2001).

The isolates of genus 3 were identified as *Klebsiella pneumoniae* according to morphological and biochemical characteristics (Table 4). *K. pneumoniae* represented 14% of the identified gram negative bacteria isolated from El Saff area. This pathogenic bacterium has been previously isolated from surface water (McIntosh and Austin, 1990; Podschn *et al.*, 2001). There are 2200 known species of *Salmonella* which cause intestinal infections such as salmonellosis. The species of genus 4 was classified as *Salmonella cloacae* because of its biochemical characteristics (Table 4). Such pathogenic bacterium constituted 11% of gram-negative bacteria from the examined water. On the other hand, isolates of genus 5 were identified as *Shigella sp* and represented 9% of the identified gram negative bacteria. This pathogenic bacterium is an invasive pathogen which causes shigellosis or Shigella-related diarrhea. On the other hand, genus 6 includes 8 isolates (8%) of gram-negative bacteria which were identified as *Proteus vulgaris* (Table 4).

4-Impact of the polluted water on the human health:

The consequences of pollution on the human race are widespread and range from a reduction in the recreational value of beaches and waterways, to unaesthetic drinking water, to serious health hazards. The concern of these people responsible for the protection of human health has turned increasingly to problems associated with chemical pollution. Industrial wastes can contain a variety of toxic inorganic, metallic, and organic compounds such as mercury and pesticides.

Table 3: The total viable bacterial counts (TVBCs) $\times 10^4$ cfu/ml water, the most probable number (MPN) of total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) /100ml water of El Saff area

Sample No.	Total viable bacteria $\times 10^4$ cfu ml		Total coliform	Faecal coliform	Faecal streptococci
	22°C	37°C			
Surface water					
Nile River water					
1	35	43	-	-	-
2	27	32	15	8	2
3	71	97	-	-	-
El Khashab and El Hager canals water					
4	96	120	275	28	10
5	192	244	225	71	59
6	103	130	275	20	69
7	16	29	10	83	5
El Saff wastewater canal					
8	187	315	1600	381	114
9	142	232	900	360	76
10	219	264	1350	310	205
11	217	280	1800	350	170
12	276	361	1800	390	75
13	207	261	1800	370	52
Groundwater					
14	50	72	-	-	-
15	62	75	-	-	-
16	59	106	25	2	4
17	67	90	-	-	-
18	14	22	-	-	-
19	206	252	350	260	40
20	180	230	900	430	210
21	15	23	-	-	-
22	9	17	-	-	-
23	20	35	-	-	-
24	5	10	-	-	-
25	11	19	-	-	-
26	18	24	-	-	-
27	11	19	-	-	-
28	18	24	-	-	-
29	2	4	-	-	-
30	11	15	-	-	-
31	6	9	-	-	-
32	41	65	-	-	-
33	63	86	-	-	-
34	47	52	-	-	-
35	19	28	-	-	-

Noteworthy to mention that, chemical wastes affect water in several different ways. They can alter the pH of a river and impact color, taste, and odor. If liquid wastes from several different sources are emptied into rivers, they may react and produce other compounds. Such reactions or changes in pH can cause materials to precipitate in the river. If the pH becomes exceedingly acid, the river will be devoid of life.

The factors to be considered here will be mercury, iron, aluminum, and manganese as well as boron, nitrate, ammonia and phosphate, because their concentration are more than the acceptable limits of drinking water.

Table 4: API 20E biochemical characteristics pathogenic of Gram-negative bacteria isolated from El Saff area

Type	Genus 1	Genus 2	Genus 3	Genus 4	Genus 5	Genus 6
ONPG	+	-	+	-	-	-
ADH	-	+	-	-	-	-
LDC	-	-	-	+	+	-
ODC	-	-	-	+	+	-
CIT	-	+	+	-	-	-
H ₂ S	-	-	-	-	-	+
URE	-	-	+	-	-	+
TDA	-	-	-	-	-	+
IND	+	-	-	-	-	+
VP	-	-	+	-	-	-
GEL	-	-	-	-	-	-
GLU	+	-	+	+	+	+
MAN	+	-	+	+	-	-
INO	-	-	+	-	-	-
SOR	+	-	+	+	-	+
RHA	+	-	+	+	-	-
SAC	-	-	+	-	-	+
MEL	+	-	+	-	-	-
AMY	-	-	+	-	-	-
ARA	+	-	+	-	-	-
OX	-	-	-	-	-	-
NO ₂	+	--	+	+	+	+
N ₂	-	-	-	-	-	-
MOB	+	+	-	+	-	+
McC	+	+	+	+	+	+
OF-O	+	+	+	+	+	+
OF-F	+	-	+	+	+	+

Where they confirmed as

Genus 1: E.coli; Genus 2: P.flouresence; Genus 3:K.pneumonia; Genus 4: Salmonella cloerasuls; Genus 5: Shigella sp.; Genus6: Proteus vulgaris.

4.I. Impact of the polluted water by mercury on the human health:

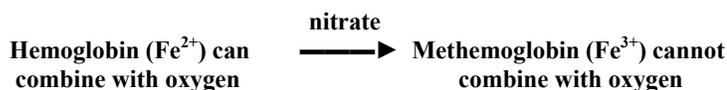
Mercury is used as a preservative and a pigment in the paint industry, in pulp manufacture, in batteries and in some medicines as a dental amalgam.

The ultimate effects of mercury in the body appear to be inhibition of enzyme action and cellular damage caused by the ability of mercury to bind tightly with sulfur-containing groups in molecules which are present in both enzymes and cell walls. Such binding is able to inactive enzymes and upset chemical reactions which they catalyze in the body. The membrane properties of cell walls get disrupted by the binding of mercury, and normal cellular activities are inhibited. The damage done to the body by mercury has been generally usually permanent.

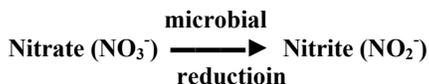
Symptoms of mercury poisoning include deafness, loss of coordination, insanity, and death. In addition methyl mercury may cause genetic damage (Chhatwal *et al.*, 1993). Also, the effects of mercury on man are abdominal pain, headache, diarrhea, hemolysis and chest pain.

4.II. Impact of the polluted water by iron on the human health:

More than 0.2mg/l is objectionable for most industrial uses. The failure of the red blood cells has been due to the conversion of their hemoglobin to a closely related substance, methemoglobin, which cannot combine with oxygen. The conversion is brought about by the action of nitrate on the iron (Fe) in the hemoglobin molecule, which oxidizes it from divalent to trivalent iron. The condition produced by nitrate (or nitrite) poisoning has been termed as methemoglobinemia.



For a nitrate to be highly toxic it must first get converted to nitrite.



4.III. Impact of the polluted water by aluminum on the human health:

Aluminum is used in alloys and for making lightweight utensil such as kitchen ware. It is used extensively in aircraft construction concentration in buildings and in electrical conductors. Aluminum compounds are used throughout the chemical industry.

Aluminum salts are used in treating water for potable supply, and the small amounts left in the finished water are regarded as harmless to consumers. Excessive amounts, however, can cause illness.

4.IV. Impact of the polluted water by manganese on the human health:

Manganese is used extensively in the steel industry for making alloys. It is also found in glass, ceramics, batteries, fertilizers and fireworks. It is discharged to surface water from industries using these elements.

The concentrations of manganese depend to a lesser extent on the concentration of sewage effluents. It may influence the taste of water at concentrations over 0.1mg/l. High doses of manganese are toxic to living organisms and this toxicity is greater at lower pH values. Manganese is an undesirable impurity in water supplies, mainly owing to a tendency to deposit black oxide stains. Manganese usually persists in the water for greater distance downstream from the pollution source than iron contained in the drainage inflows.

More than 0.2mg/l precipitates upon oxidation, causes undesirable tastes, deposits, on foods during cooking, stains plumbing fixtures and laundry and fosters growth in reservoirs, filters and distribution systems. Noteworthy to mention that, most water used in industrial fields containing more than 0.2mg/l.

4.V. Impact of the polluted water by boron on the human health:

It is present in washing powders as a water softener. Boron occurs in surface water as a result of its presence in discharged wastewater because of its use in domestic products.

In small doses, boron is harmless to mammals, but high dosages can affect the central nervous system, and prolonged ingestion gives rise to the condition known as borism.

4.VI. Impact of the polluted water by nitrates on the human health:

Water containing large amounts of nitrate (more than 100mg/l) is bitter tasting and may cause physiological distress. Water from shallow wells containing more than 45mg/l has been reported to cause methemoglobinemia in infants. Small amounts of nitrate help reduce cracking of high-pressure boiler steel.

Increased nitrate levels in water supplies can be fatal to infants. At these levels the disease methemoglobinemia is induced by intestinal bacteria that have the ability to convert nitrate to nitrite is then absorbed into the bloodstream, where it binds with hemoglobin. This binding action effectively prevents the hemoglobin to accept the oxygen that is necessary for respiration. The red blood cells lose their capacity to carry oxygen, causing the blood to turn dark and resulting in death form asphyxiations. One of the symptoms of nitrate poisoning is a bluish discoloration of the skin and mucous membranes.

4.VII. Impact of the polluted water by ammonia on the human health:

Toxicological effects are observed only at exposures above about 200mg/Kg of body weight.

4.VIII. Impact of the polluted water by phosphate on the human health:

Almost 80% of phosphate production goes into fertilizers. Other uses of phosphate include manufacture of soaps and detergents, pesticides and animal feed supplements. Phosphates are used extensively in the production of washing powders.

Phosphates are present in surface waters as a result of municipal sewage and industrial wastewater discharge.

High concentrations of phosphorus may present in certain industrial wastewater. Phosphorus-based fertilizers are extensively used in agriculture.

Phosphorus, in the concentrations that occurs in natural waters, is not harmful to health. The main concern is about the growth of algae, because some of these organisms, the blue/green algae, can produce toxins as a by-product of their photosynthesis in water supply reservoirs and recreational lakes.

Summary and conclusion:

The current research is carried out to throw light on the pollutants detection and their impact on human health in El Saff area, Giza governorate, Egypt.

To achieve the aim of this research, water pollution was discussed on the basis of determining of inorganic and biological as well as bacteriological constituents during analyses of thirty five (35) water samples collected within August 2011. The collected water samples are corresponding to all available water sources included 13 surface water (Nile River, and El Khashab and El Hager canals as well as Elsaff wastw water canal) and 22 groundwater samples.

The results revealed that the surface water (Nile River, and El Khashab and El Hager canals) as well as the groundwater samples are variably polluted by Fe^{3+} , Hg^{2+} , Mn^{2+} , Al^{3+} , B^{3+} , NO_3^- and NH_4^+ as well as BOD_5 and COD. Also some bacteriological pollutants were detected in surface and groundwater samples.

The high concentrations of Hg^{2+} , Fe^{3+} and Al^{3+} ions in the Nile river water samples are due to that their locations at the outlets of El Saff wastewater canal which release into Nile River water across the floods runway, where El Saff canal is considered as an acceptor for the industrial wastes that coming from the factories existed in Helwan area which located at north of the study area. The high concentrations of Fe^{3+} , Hg^{2+} and Mn^{2+} ions in El Khashab and El Hager canals are due to that these canals are recharged from Nile River (which is exactly polluted by some of these contaminants as Fe^{3+} and Hg^{2+}) and also these canals received industrial wastes from factories existed in the study area that discharged their wastes in these canals at these localities, while the canals are polluted by Pb^{2+} ions due to the high traffic intensity. In addition, high Fe^{3+} , Hg^{2+} , Mn^{2+} and Pb^{2+} ions concentrations are detected in irrigation canals that can be attributed to the deposition of most of the waste suspended materials in these canals. The high concentrations of Fe^{3+} , Hg^{2+} , Al^{3+} and Zn^{2+} ions in the majority of groundwater confirm that there is a seepage from El Khashab and El Hager canals and, from El Saff wastewater canal that contains relatively high soluble metals as well as downward infiltration of excess amounts of irrigation water rich in fertilizers and pesticides to the groundwater aquifer.

The relatively high concentrations of boron in El Saff wastewater canal is due to the discharge of sewage water and industrial wastewater rich in sodium tetra borate (borax) which is widely used as a cleaning aid. While the high boron concentrations in the groundwater is due to downward infiltration of excess irrigation water and drainage water rich in fertilizers and pesticides.

Noteworthy to mention that, the relatively high NO_3^- concentrations in some groundwater samples are considered critical concentrations and may increase by time. The primary source of nitrates in groundwater is the leaching of nitrate salts into the groundwater supply from agricultural fertilization and the seepage of sewage water.

About 9% of the groundwater samples have nitrite concentrations more than the permissible limit of pollution, this is due to the effect of the wastewater of El Saff canal (seepage from El Saff wastewater canal to groundwater at these localities).

The majority of the Nile River and its canals water samples have NH_4^+ concentrations higher than the permissible limit of pollution, this is due to the drainage of El Saff wastewater canal in Nile River and, El Khashab and El Hager canals at these sites. The high concentration of ammonia in groundwater is due to the seepage from El Saff wastewater canal at these localities and irrigation return flow rich in ammonium fertilizers as ammonium phosphate $(\text{NH}_4)_3\text{PO}_4$ and ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$. Also, wastewater, animal manure, and refuse dumps may be considered as important sources for elevated ammonium in groundwater.

The relatively high concentration of phosphate in El Khashab and El Hager canals is attributed to the disposal of wastewater in them at these sites. The relatively high phosphate concentrations in groundwater samples referred to the seepage from El Saff wastewater canal at these localities and return flow after irrigation.

All water samples El Khashab and El Hager canals in the study area are unsuitable for drinking purpose, as they have BOD_5 concentrations more than the acceptable limit of pollution, this is due to the drainage of both wastewater (houses drain) and the outlets of factories especially for chemical, pulp and food industries into these canals. About 40% of groundwater samples are contaminated as they have BOD_5 concentrations more than the safe limit for drinking water. This is due to seepage from El Khashab and El Hager canals, in addition to return flow after irrigation.

All Nile River and, El Khashab and El Hager canals water samples in the study area have high values of COD concentrations more than the permissible limit. These high values are due to drainage of El Saff wastewater canal into surface water in addition to the outlets of the pulp and paper industry factories where the chemical oxygen demand (COD) resulting from industrial wastewater. For groundwater samples, the majority of the collected samples (95%) are unsuitable for drinking purpose as they have COD concentrations more than the

permissible limit of pollution. The high value for groundwater samples is due to the seepage from El Saff wastewater canal and, El khashab and El Hager canals to groundwater.

The bacteriological analyses involved total viable bacterial counts (TVBCs), total coliforms (TC) and estimation of faecal coliforms (FC), faecal streptococci and pathogenic bacteria. The bacteriological analyses showed that TVBCs ranged from 2×10^4 to 276×10^4 cfu/ml and from 4×10^4 to 351×10^4 cfu/ml at 22°C and 37°C, respectively. Several pathogenic bacterial isolates representing six genera were identified to species level. These included, *Esherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas flourcsence*, *Salmonella colerasuis*, *Shigella sp.* and *Proteus vulgaris*. The results of the present investigation revealed that, the River Nile water at El saff area was subjected to sewage pollution during the study period.

The most important pollution sources in the study area include the wastewater produced from the industrial complex at Helwan area in addition to the wastewater which is discharged into Nile River and its canals. Also, the seepage of irrigation water which contain excessive amount of fertilizers and pesticides into groundwater.

So all water sources in the concerned area are unsuitable for drinking purposes, while these water resources are suitable for irrigation except El Saff wastewater canal.

Finally it can be concluded from this study that the majority of water resources in the study area is contaminated variably by different kinds of pollutant which are very serious to people's health, animals, soil and plant. Thus, monitoring of chemical and microbial quality of water is must to control the spreading of pathogens transmitted by contaminated water that had been previously isolated from surface water. So, it is essential to reduce or eliminate the pollutants content in the wastewaters discharged into the water resources.

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