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Evaluation of water pollution using physicochemical parameters, heavy metals concentrations, and organic pollutants: Study area El-Behaira Governorate.

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Abstract

The objective of this study was to examine the extent of bioaccumulation of organic contaminants and heavy metals in water within the El-Behaira Governorate region. Water is a fundamental need for life. The issue of water pollution has risen to a worldwide scale, necessitating a continuous assessment of water resource policies to combat this problem. Heavy metals are not often found in the Earth's crust; nevertheless, they are the main cause of water pollution and are found in many aspects of modern life.

Three water catchment areas (Damanhur, Kafr-El Dawar, El-Mahmoudia) in EL-Behaira Governorate, Egypt were collected to assess the types of water pollutants. The physicochemical properties of water as temperature, pH value, electric conductivity (EC), total alkalinity ($CaCO_3$), Turbidity (NTU), and salinity (NaCl) were appreciated. Heavy metals such as Aluminum (Al), Iron (Fe), Lead (Pb), Nitrite (NO_2^-), and Sulphate (SO_4^{-2}) were determined by the atomic absorption spectrophotometry. Also, organic pollutants were analyzed using the gas-chromatography mass spectrometry (GC-MS).

The obtained results showed that the mean values of temperature (24.44 - 26.12°C), pH value was (6.76 - 8.23), electric conductivity (EC) ranged between (443.4-2001.1 mS/ cm), total alkalinity was (19.4- 137 ppm), turbidity was (6.43 - 9.17 NTU) and salinity was (0.0183- 0.0358 mg/l). The results confirmed the presence of some heavy metals such as Al (1175- 9002 mg/l), Fe (0.210- 0.724 mg/l), Pb (19.21- 20.73 mg/l), NO_2^- (0.012- 0.120 mg/l) and SO_4^{-2} (114.54 - 818.5 mg/l). The obtained values were compared with allowable levels stated by WHO guidelines (2017) and Egyptian guidelines (No 92/2013) for the River Nile protection from pollution. Organic pollutants were detected in the study area and verified in the NIST 2008 (National Institute of Standard and Technology Library). This reveals a high exposure potential for human health. It is thus recommended that further research be conducted to determine the potential health risks associated with these organic pollutants among vulnerable communities, through epidemiological studies. It was recommended that surface water quality be shielded from environmental contamination.

Keywords: Water Pollution, Heavy metals, Electric conductivity (EC), Organic pollutants- GC-MS.

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Introduction

Water is a crucial substance required for sustaining important human functions such as nutrition, respiration, circulation, waste elimination, and reproduction. Hence, it is essential to ensure the sustenance of sufficient food availability and a healthy habitat for all living organisms (1). Enhanced water quality will expedite the achievement of the Millenium Development Goals (MDGs) as Getting rid of extreme poverty and hunger, providing basic education, lessening child mortality, improving the health of mothers, and preventing human immunodeficiency (2).

Pollution has caused major alterations to water systems. A lot of issues like industrial debris, herbicides, pesticides, heavy metals, and air pollutants contaminated water led to severe illnesses in humans. Water contamination is disrupting the overall ecosystem of aquatic environments (3). Polluted water is a global source of deaths and diseases, resulting in roughly 19,000 fatalities every day (4). Various physicochemical factors have been identified as indicators of water quality, including taste, color, odor, pH, electrical conductivity (EC), hardness, alkalinity, and salts. These characteristics are influenced by a variety of factors including precipitation, climate, soil type, vegetation, geology, flow conditions, groundwater, and human activities (5). The most significant risk to water quality induced by industries and municipalities is the primary sources of pollution that represent. The increasing global population, the consequences of climate change, and lifestyle changes are causing major stresses on our essential water supplies, resulting in widespread water stress in numerous countries (6). Industrial zones, mining activities, waste materials from mining operations, fertilizers, runoff from agricultural activities, sewage sludge, animal waste, irrigation with wastewater, organic pollutants, and pesticides all contribute to the poisoning of water with heavy metals. Several water resources in Egypt are contaminated with heavy metals such as iron (Fe), manganese (Mn), copper (Cu), cadmium (Cd), cobalt (Co), nickel (Ni), lead (Pb), Nitrite and sulfide. These elements have a specific gravity larger than four and their atomic weight ranges from 63.545 to 200.5 grams. The elevated quantities and accumulation of these metals present a significant health risk to humans (7).

The rivers as the ecosystems are essential for establishing the natural, cultural, and economic features of any country. The Nile is Egypt's main water source and a crucial economic river that supports agriculture and sustains the surrounding ecology (8). A multitude of pollutants are significantly contributing to the contamination of the river water. The Nile Valley and Delta are among the most ancient agricultural regions on Earth. The Nile Delta is among the locations that face threats such as water logging, soil compaction, salinization, and alkalinization. The Delta region has surface water irrigation, leading to a swift elevation in water tables and a subsequent rise in soil salinity (9).

Now, Egypt is confronted with a significant issue of environmental water contamination, which needs more effort and environmental consciousness. According to the 2020 study by the African Development Bank, 80% of the nation's industrial waste is released into surface water bodies without undergoing any treatment. Surface water sources in Egypt are regarded as highly susceptible water sources (10). The growing population necessitates more social, economic, and environmental needs, resulting in heightened environmental effects. Consequently, it is crucial to identify an appropriate and efficient approach to promptly monitor these environmental impacts and fluctuations (11).

Water shortages in Egypt are caused by various factors, including the contamination of surface water bodies and streams due to industrial activity and harmful human practices (12). Most of the wastewater is discharged into rivers and canals, in both urban and rural areas due to improper irrigation practices and water mismanagement. Consequently, the monitoring, collecting, analysis, and interpretation of data are necessary to assess water quality.

In this study on El-Behaira Governorate, it was aimed to determine heavy metals concentrations, reveal the pollution problems, determine the suitability level in terms of aquatic life, and classify the quality of water following Environmental Protection Laws.

Methodology

Environmental Description of the Study Area

The location of the study area (Fig.1) is located in El-Behaira Governorate-Egypt between longitudes 30° 17' 54.42′′and 30° 36' 27′.96′′East and latitudes 30° 54' 51′.1′′and 31° 7' 59.34′′North. The area at concern accounts for around 9% of Egypt's total land area. The governorate has dry Mediterranean climatic conditions. The United Nations study provides a describe the geological parameters of El-Behaira governorate (13). The presence of two aquifers can be observed in its formation: the Nile aquifer, which is mostly located along the eastern border and to a lesser extent along the northern shore, and the Moghra aquifer, which covers the rest of the governorate. The Nile aquifer is a relatively shallow underground water source that is mostly replenished by the seepage of surplus irrigation water. It accounts for approximately 85% of the total amount of groundwater extracted in Egypt (14). The Moghra aquifer is replenished by both rainfall and lateral input from the Nile, which also includes salty water. The average lowest and maximum annual temperatures are 12.6 °C and 26.2°C respectively, indicating a Thermal temperature regime. The yearly precipitation is 83.7 mm. This location is chosen due to its well-established reputation for agricultural land being susceptible to erosion and urban encroachment.

Samples Collection

In this survey, samples were collected from three areas each area (10 samples) Fig (2):

Area I: Damanhur district located in the north-central part of the Nile Delta is representative of the territory of the Nile River (from drinking Water Station).

Area II: Kafr-EL-Dawar is a major industrial city on the Nile Delta and is surrounded by many industrial activities (from plastic factory drainage named MEGA PLAST for packaging materials).

Area III: El-Mahmoudia Canal is near the northern edge of the west Nile valley. The route of the canal starts at the Rosetta branch of the Nile and goes for 77.170 km. Most of the water treatment plants (WTPs) in Alexandria and El-Behaira are supplied by the El-Mahmoudia canal.

Figure (1): El-Behaira Government study area**.**

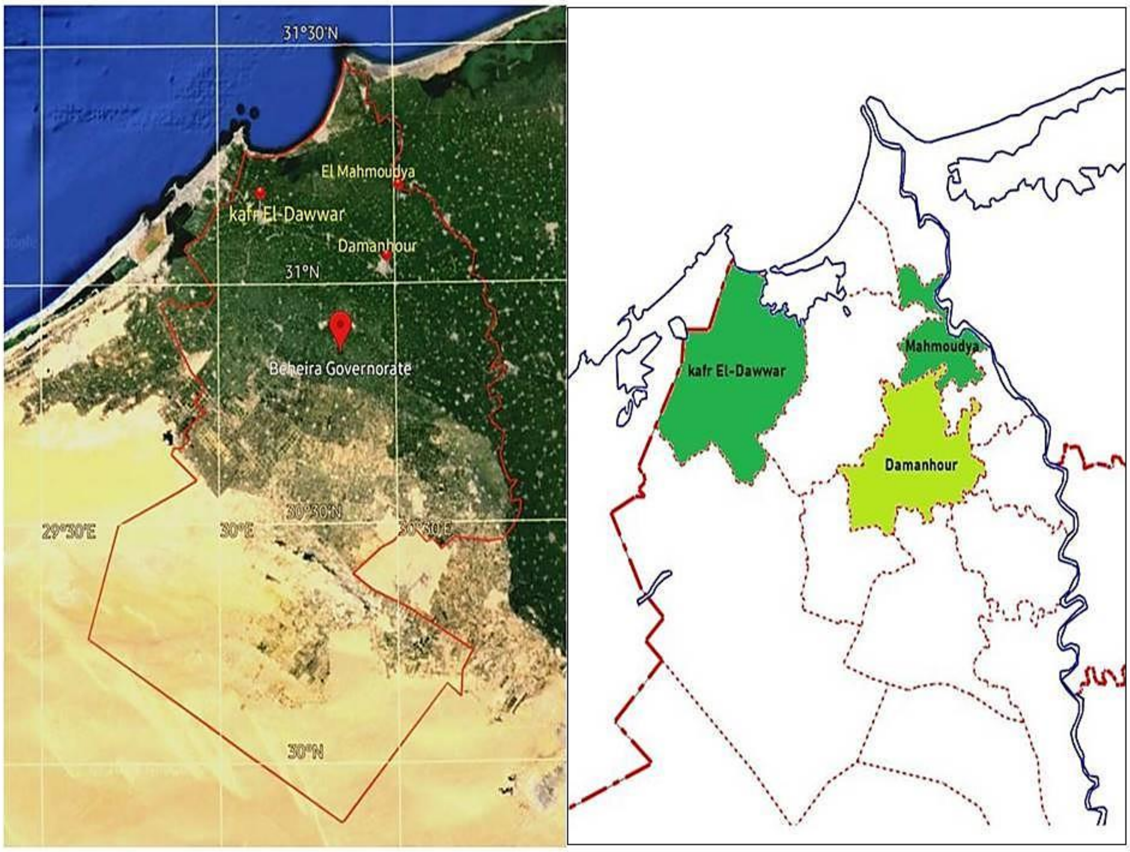

Figure (2): Catchment areas (Damanhur, Kafr-El Dawar, El-Mahmoudia) in EL-Behaira Governorate, Egypt.

Preparation of the Samples

To prevent microbiological activity, approximately 2 milliliters of 10% HNO_3 acid were applied to each 500-milliliter plastic bottle before adding the samples. Before analysis, all water samples were properly labeled, placed in plastic bottles, and then transferred to the laboratory. A zooplankton net with a mesh size of 100 μm and a Whatman GF/F filter with a pore diameter of 0.7 μm were used to filter and sift the samples that were collected (15).

Physicochemical Analyses

Chemical analysis was performed at the Central Laboratory for Water and Environmental Technology (CLWET) of the Faculty of Science, Damanhur University, Egypt. Temperature, pH value measured by pH-meter (model, 181, serial No.0708149, UK), electric conductivity (EC) measured by a calibrated conductivity meter, total alkalinity ($CaCO_3$), turbidity (NTU) and salinity (NaCl) were measured according to the reference methodology reported by American Public Health Association APHA (16). Data were compared to the listed permissible limits of Egyptian guidelines (No 92/2013) for the River Nile protection from pollution (17) and WHO (2017) (18).

Appreciation of Heavy Metals

Concentrations of heavy metals (Aluminum (Al), Iron (Fe), Lead (Pb), Nitrite (NO_2^-), and Sulphate (SO_4^{-2}) in water samples were determined by atomic absorption spectrophotometer (Model Thermo Scientific ICE 3000 series) following the method of APHA (19).

Appreciation of Organic Pollutants

The technique of Gas Chromatography-Mass Spectrometry (GC–MS) was employed to identify the chemical components present in water samples from various locations. The GC-MS analysis was conducted using an Agilent GC 7890A coupled with a triple-axis detector 5975C single quadrupole mass spectrometer. The chromatographic column used was an Agilent HP 5MS column with dimensions of 30m in length, 0.25mm in diameter, and a film thickness of 0.25μm. The gas carrier used was high-purity helium, and it was flowing at a rate of 1mL/min. The temperature of the injector was set to 250°C, and it was fitted with a splitless injector operating at a ratio of 20:1. The source temperature of the mass spectrometer (MS) was adjusted to 230°C, while the quad temperature was set at 150°C. The oven temperature started at 40°C and was maintained for 1 minute. It was then raised to 150°C at a rate of 10°C per minute and kept for 1 minute. Finally, it was further increased to 300°C at a rate of 10°C per minute and held for 1 minute. The injection volume was 1μL, and the scan range was set from 50 to 800 mass ranges. The electron energy was set at 70eV, and there was a solvent delay of 3 minutes. Ultimately, unidentified substances were recognized by contrasting the spectra with those of the NIST 2008 (National Institute of Standard and Technology Library). The time needed to analyze one sample was 29 minutes (20).

Statistical Analysis

Data were expressed as mean± standard deviation and analyzed using one-way analysis of variance (ANOVA) followed by Duncan's test as a post-hoc test using the IBM SPSS Statistics 22.0 software package.

Results and Discussion

Physicochemical properties of water samples

The physical and chemical characteristics are crucial in regulating life in aquatic ecosystems, resulting in alterations to the variety and community structure of the aquatic environment (21). Results in table (1) show the physicochemical properties of water samples (Damanhur-Kafr-EL-Dawar-El-Mahmoudia) compared with Egyptian guidelines (No 92/2013) and WHO (2017). The quality of water considerably varies from location to location.

There exist significant variations in typical surface temperatures and pH values across three distinct locations. The water temperature is a crucial determinant that influences the biological activity of aquatic organisms and the overall water quality (22). The changes in this parameter result from seasonal temperature changes (23). The pH value serves as an indicator of the chemical and biological characteristics of water. It is utilized for categorizing weak acids and bases. This segregation impacts the toxicity of several substances. The pH value was determined to be below the standard levels, maybe as a result of organic matter drainage (24). Moreover, pH is not only influenced by CO_2 exchange but also by organic and inorganic pollution in the water.

The previous observations recorded a significant increase ($p< 0.05$) in EC in the El-Mahmoudia sample than Damanhur and Kafr-EL-Dawar areas. Electrical conductivity (EC) is a crucial factor for aquatic goods, and the conductivity exceeds 100 µs/cm as pollution levels rise (25). EC of the surface water was found to be within the usual range, but the groundwater exhibited mild to moderate salt issues. Thus, the electrical conductivity of groundwater, as per this threshold, might lead to a mild salinity issue (26). Indeed, to combat this salinity it is possible to apply normal water to remove the salts and these results are in agreement with the current study. Water conductivity is the measure of water's capacity to conduct electrical current in the presence of dissolved minerals such as chloride, magnesium, and calcium. Conductivity can be employed as a method for detecting the presence of chemicals in water (27).

The presence of total alkalinity ($CaCO_3$) is crucial in aquatic biology since it enhances the accessibility of inorganic carbon for plants. Additionally, it tends to act as a buffer for water, preventing significant fluctuations in pH levels. A grasp of water quality requires a fundamental understanding of the interconnections between pH, carbon dioxide, and alkalinity (28). Furthermore, it is defined as the overall concentration of bases that may be titrated, given in terms of calcium carbonate ($CaCO_3$). Calcium carbonate is used as a reference for measuring alkalinity, as it is frequently added to raise the pH and alkalinity of acidic water (29). The total alkalinity in pure water would be only 1.58 mg/L as $CaCO_3$.

The turbidity level of samples in the present study is higher than the permissible limit value of WHO is 5 (NTU). Turbidity varies from muddy particles in water. Turbidity is the quantification of the haziness and cloudiness of water resulting from the presence of suspended solid particles. It is often measured in Nephelometric Turbidity Units (NTU). Elevated turbidity levels can lead to a rise in water temperature due to the absorption of heat by the suspended particles from sunlight. The development rate of aquatic plants is hindered by the inability of sunlight to penetrate through murky water, leading to disruption of the photosynthesis process. In the present research, the concentration turbidity of the El-Mahmoudia area rises from other areas (Damanhur-Kafr-EL-Dawar). According to the World Health Organization (WHO), tap water is deemed safe as long as its turbidity level remains below 5 NTU, which is the threshold for drinkability (30). On the contrary, the water of Damanhur shows high turbidity measurement.

The salinity gradient is a prominent element of every ecosystem (31). In the present study, the concentration of NaCl in Kafr-EL-Dawar and El-Mahmoudia areas significantly increased in the Damanhur sample. A multitude of industrial sectors are prone to producing wastewater with high salinity content. The release of wastewater that simultaneously contains significant levels of salt and organic matter. Marine and freshwater environments exhibit significant disparities in the concentration and ratio of ions.

Table (1): Physicochemical characteristics of water samples (Damanhur - Kafr-EL-Dawar- El-Mahmoudia) compared with Egyptian guidelines (No 92/2013): WHO (2017).

Parameters	Damanhur area	Kafr-EL-Dawar Area	El-Mahmoudia Area	Egyptian guidelines (No 92/2013)	WHO (2017)
Temp (°C)	26.12 ± 3.54 a	24.44 ± 5.11 b	25.98 ± 6.16 b		
pH	8.23 ± 0.22 a	7.68 ± 0.05 a	6.76 ± 0.65 b	range (7–8.5)	range (6.5–8.5)
Electric conductivity (EC) mS/ cm	443.4 ± 11.52 c	758.5 ± 13.01 b	2001.1± 25.51 a		250
Total alkalinity ($CaCO_3$) ppm	19.4 ± 0.1 c	47.6 ± 0.5 b	137 ± 11 a	10-15	
Turbidity (NTU)	6.43 ± 1.31b	7.43 ± 2.1b	9.17 ± 2.66 a	5	< 5 NTU
Salinity (NaCl) mg/ l	0.0183±0.006a	0.0325±0.01ab	0.0358±0.01ab		0.020-0.070

This means within the same raw carry different superscripts are significantly different (P <0.05). Represented data mean ± SD.

Heavy metals in water samples

The atomic absorption spectrophotometer was performed to assess the concentration of heavy metals (Al, Fe, Pb, NO_2^- and SO_4^{-2}) in the study area (table 2). It has been reported that the concentration of Al in El-Mahmoudia and Kafr-EL-Dawar is greater than Damanhur area because of the plastic factory drainage named (MEGA PLAST) and agricultural drain which is present in these stations of water sources.

Heavy metal cations in drinking water are often the primary hazardous compounds in the environment that pose a threat to human health. Contamination of agricultural soils and water with heavy metals can lead to soil dysfunction, damage to plants, and pose a risk to human health by contaminating the food chain (32).

Aluminum may exist in multiple forms in water. Furthermore, it can create complexes with a huge range of chemical molecules (e.g. humic or fulvic acids) and inorganic ligands (e.g. fluoride, chloride, and sulfate). The interaction between aluminum and water is intricate, and several chemical factors, such as pH, influence the types of aluminum compounds that exist in water-based solutions (33).

Al exhibits the lowest level of solubility in the pH range of 5.5-6.0 in pure water. The concentration of total dissolved aluminum tends to rise for pH values that are either higher or lower than this range (34). So, in the present study, there was a relationship between the increased values of pH in the different areas under study and the concentration of Al in the water samples.

The percentage of aluminum in natural and drinking water can vary considerably based on numerous physicochemical factors related to water pollution. The presence of aluminum has caused debates over potential hazards, due to its putative association with Alzheimer's disease or dialysis encephalopathy (35). According to Egyptian guidelines (No 92/2013) Al heavy metal must be undetected.

From the analyzed results, it was found that the concentration of Fe in Kafr-EL-Dawar recorded a significant increase more than in Damanhur and El-Mahmoudia. Iron is known to have a crucial role as an essential element in all life systems. The presence of iron in groundwater can result from either natural or human activities. Furthermore, due to human activities such as mining or poor disposal of wastewater, water sources get polluted with metallic metals. These ions have a valence of two in the absence of oxygen. Once the required circumstances for oxidation are met and there is an ample supply of oxygen, these ions can reach their maximum capabilities. Consuming drinking water that contains a high percentage of iron might potentially result in a liver illness known as haemosiderosis (36).

The quantities of heavy metals increased significantly upstream, namely at the sites of Kafr El-Dawar. This is likely attributed to the presence of home sewage and the run-off from highly cultivated regions. Kafr El-Dawar is a prominent industrial city located on the Nile Delta in the northern region of Egypt. Regrettably, this region is currently experiencing the discharge of industrial effluents into the irrigation canal and agricultural drains. The Al-Mahmoudia Canal is situated on the northern border of the Behaira Governorate. The canal is contaminated by several sources of contaminants. These contaminants result in substantial degradation of the water quality in the canal.

Lead concentration in this investigation reported high levels in three areas (Damanhur, Kafr-EL-Dawar, and El-Mahmoudia). Lead exposure continues to be a significant issue in public health. Pb is a potentially hazardous metal that, upon absorption by the body, builds up in the bloodstream, bones, and other organs including the liver, kidneys, brain, and skin. The detrimental health consequences of lead can manifest both acutely and chronically due to the human body's limited ability to eliminate it (37).

Pb has been demonstrated to impact the functioning of several systems in the human body, including the hepatic, reproductive, endocrine, immunological, and gastrointestinal systems. Convincing data indicates that lead and its inorganic compounds have a carcinogenic impact on human beings. The most prevalent heavy metals are responsible for environmental and food pollution due to their non-degradable nature. Their long-term buildup in organs such as the liver, heart, and muscles can lead to several acute or chronic illnesses in humans. Particularly, Pb can threaten the health of children and provide mental retardation (38).

The nitrogen entering surface waterways can originate from natural, household, and agricultural sources. The sources of nitrite (NO_2) in water include organic materials, fertilizers, and some minerals. The presence of nitrite in water serves as an indicator of pollution. Fertilizer compounds that are high in nitrogen lead to a depletion of dissolved oxygen in rivers and other water sources, resulting in severe consequences for marine life. Nitrogen fertilizers possess a notable degree of water solubility, leading to an elevated rate of runoff and leaching. Consequently, this phenomenon contributes to the polluting of groundwater. The concentration of NO_2^- in the study area is represented by normal limits according to Egyptian guidelines (No 92/2013).

The concentration of sulphate (SO_4^{-2}) in the Kafr-EL-Dawar and El-Mahmoudia regions showed a significant increase compared to Damanhur, ranging from 114.54 to 818.5 mg/l. Sulphate is an oxide of sulphur that is commonly present in water and soil particles when oxygen is present. The Minnesota Pollution Control Agency (MPCA) has reported that sulphate is found at considerably higher concentrations in various groundwater and surface water systems due to its increased solubility in water (39).

Widespread combustion activities globally lead to the release of substantial amounts of sulphur into the environment. Sulfur undergoes further oxidation to become sulfate, which is subsequently deposited on the ground surface by either rainfall or dry deposition. Because sulfate is a common dissolved ion, it moves easily within the aquifer system. These results align with the conclusions of a previous study (40).

Typically, humans can come into contact with heavy metals by external means, such as physical touch, or internal means, such as consuming water that is polluted with heavy metals. This exposure can lead to health hazards, particularly in regions where industrial and agricultural activity is increasing.

Organic pollutants in water samples

The GC–MS analysis of organic pollutants was determined for three areas (Damanhur, Kafr-EL-Dawar, and El-Mahmoudia) and recorded in Tables (3, 4, and 5), respectively. The results showed that many organic compounds such as 1-Octadecanamine, 1-Dodecanamine, 1-Heptadecanamine, quinuclidinium-methanesulfonate, 4,6-dibromo-1methyl-1H-azepin-3, Diethyl 3-chloro-2-hydroxypropyl, Ethyl 2-(diethoxyphosphoryl), Diethyl 3-chloro-2-hydroxypropyl, 2H-3,9a-Methano-1-benzoxepin, 1-Butanamine and Isobutylamine in Damanhur area.

In Kafr-EL-Dawar GC-MS of organic pollutants reported 1-Carboxycyclopropane-2-acetic acid, 2-Propenamide, Carbamic acid, S-(-)-2-Methylbutylamine, 1-Butanamine, Cyclohexane, Pyrimidine, o-2-Pentylhydroxylamine, 1-Heptadecanamine, 1,2-Ethanediamine, 1,6-Hexanediamine, Benzoic acid, 3-Amino-2-phenazinol ditms, and Benzeneacetic acid.

Results in El-Mahmoudia showed the presence of Silane, trimethyl[5-methyl-2-(1-methylethyl) phenoxy], Tetrasiloxane, decamethyl, Methyltris(trimethylsiloxy) silane, Propiophenone, 2'-(trimethylsiloxy) Silicic acid and diethyl bis(trimethylsilyl) ester as the major compounds detected mostly in this area. These results were identified and confirmed using NIST 2008 mass spectral libraries.

Organic substances exhibit resistance to degradation via chemical, biological, and photolytic mechanisms. They possess hazardous properties and have a detrimental impact on both human health and the global ecosystem. In recent years, there has been widespread concern about the presence of emerging organic pollutants (EOPs) in the aquatic environment (41). These pollutants come from both direct sources and diffuse sources. The substances mentioned encompass medications, industrial goods and by-products, personal care items, and insecticides. These pollutants are generated daily in significant quantities and purposefully or accidentally discharged into bodies of water.

Water pollution caused by persistent organic aromatic compounds is a growing environmental concern that is gaining the interest of environmental experts. The bulk of these stubborn pollutants consist of industrial waste, textile dyes, medicines, and personal care items that are released into wastewater (42).

In Egypt, the widespread and frequent use of pesticides in agriculture, often applied over large areas of crop fields, is acknowledged as a significant cause of water pollution through the spread of organic pollutants. This pollution occurs primarily through the leaching of pesticides into the underlying aquifers or through runoff into surface waters (43).

The origins, behavior, and environmental impacts of key types of organic pollutants often found in water, including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, dye pollutants, and antibiotics, are analyzed (44).

Table (2): Heavy metals concentration of water samples (Damanhur - Kafr-EL-Dawar- El-Mahmoudia) compared with Egyptian guidelines (No 92/2013): WHO (2017).

Heavy metals (mg/l)	Damanhur area	Kafr-EL-Dawar Area	El-Mahmoudia area	Egyptian guidelines (No 92/2013)	WHO (2017)
Aluminum (Al)	1175 ± 23 b	8944 ± 45 a	9002 ±207 a	ND	ND
Iron (Fe)	0.210±0.05c	0.724± 0.1a	0.63± 0.085b	<0.5	ND
Lead (Pb)	20.73±0.24 b	22.46± 0.21 a	19.21± 0.11 c		ND
Nitrite (NO_2^-)	0.025 ± 0.019 b	0.012 ± 0.002 c	0.120 ± 0.001a	0.3	0.05
Sulphate (SO_4^{-2})	114.54± 21.1 c	818.5±52.3 a	654.64±25.3 b	<200	

This means within the same raw carry different superscripts are significantly different (P <0.05). Represented data are mean ± SD. ND: Not detected

Table (3): GC-MS analysis of Damanhur sample area and verified in the NIST 2008 (National Institute of Standard and Technology Library).

Peak no.	RT (min)	Name of compounds	Quality	Area (Ab*s)
1	21.011	1-Octadecanamine, 1-Dodecanamine, 1-Heptadecanamine	45	1528455
2	34.143	quinuclidinium-methanesulfonate	17	263227
3	34.210	4,6-dibromo-1methyl-1H-azepin-3	15	405836
4	34.259	Diethyl 3-chloro-2-hydroxypropyl	13	700738
5	34.301	Ethyl 2-(diethoxyphosphoryl), Diethyl 3-chloro-2-hydroxypropyl	21	456268
6	34.375	2H-3,9a-Methano-1-benzoxepin	13	1173406
7	34.516	1-Butanamine, Isobutylamine	22	3535150
8	34.566	Guanidine, Ethyl 5,5-diethoxyvalerate	17	1302007
9	34.698	N-(3-Methylbutyl)acetamide	21	3939231
10	34.740	2-Octenoic acid	17	1964952
11	34.822	Heptane, 1-(ethenylthio)	12	1747433
12	34.880	beta.-Chloroethylurea, Isobutylamine, 1-Butanamine	23	1500585
13	34.922	Diethyl 3-chloro-2-hydroxypropyl	8	1376581
14	35.104	N-(3-Methylbutyl)acetamide, 1-Butanamine	23	3615395
15	35.170	1-Propanamine	16	1784244
16	35.344	quinuclidinium-methanesulfonate	6	1600522
17	35.460	N-(3-Methylbutyl)acetamide, 1-Butanamine	26	494997
18	44.703	Tetrasiloxane, decamethyl, Silicone grease	43	160151
19	45.498	Octasiloxane, 1-Benzazirene-1-carboxylic acid, 2-[(trimethylsilyl)oxy]-5-methyl	87	58178710
20	47.932	1-Benzazirene-1-carboxylic acid, Propiophenone, Cyclotrisiloxane, Cyclotrisiloxane	53	5425031847
21	48.048	Propiophenone, Cyclotrisiloxane	43	686409307
22	48.081	1-Benzazirene-1-carboxylic acid	53	147606393
23	48.197	Propiophenone, Cyclotrisiloxane	43	517453014

Table (4): GC-MS analysis of Kafr-El Dawar sample area and verified in the NIST 2008 (National Institute of Standard and Technology Library).

Peak no.	RT (min)	Name of compounds	Quality	Area (Ab∗s)
1	21.356	1-Carboxycyclopropane-2-acetic acid, 2-Propenamide, Carbamic acid	18	4740584
2	21.679	S-(-)-2-Methylbutylamine, 1-Butanamine, Cyclohexane	27	3509712
3	21.712	Pyrimidine, o-2-Pentylhydroxylamine	4	3812944
4	22.102	1-Heptadecanamine, 1,2-Ethanediamine, 1,6-Hexanediamine	28	3681962
5	22.888	Benzoic acid, 3-Amino-2-phenazinol ditms, Benzeneacetic acid	38	5122684
6	23.195	DL-Leucine, 2-Piperidinone, 1,3,2-Dioxaborolane	32	2423776
7	24.387	Carbamic acid, (cyanoacetyl)-, 1H-Pyrrole-2,5-dione	22	6683773
8	24.487	2H-Pyran, o-2-Pentylhydroxylamine	10	4409277
9	25.158	Taurolidine, Hydroperoxide	15	2354420
10	25.489	METHYL ETHANETHIOLSULFINATE	6	1952054
11	25.762	Taurolidine, Diethyl 3-chloro-2-hydroxypropyl, o-2-Pentylhydroxylamine	8	1590994
12	26.234	Cyclodecasiloxane, Heptasiloxane, Iron	64	4643967
13	26.317	2-Octenoic acid	6	5426364
14	26.450	Isibutyltributylstannane	2	2879940
15	26.880	4,6-dibromo-1methyl-1H-azepin-3	9	765073
16	26.971	4,6-dibromo-1methyl-1H-azepin-3	7	3330201
17	27.278	Glycine, furan-2-yl-methyl ester, 2-(2-Thienyl)ethylamine	2	2169611
18	27.659	Hydantoic acid, Isobutylamine, Urea, butyl-	28	1085260
19	27.866	2-Octenoic acid	3	3309913
20	27.915	Hydantoic acid, Urea, (2-ethylhexyl)-	18	2727509
21	28.164	2H-3,9a-Methano-1-benzoxepin	10	1614618
22	28.214	quinuclidinium-methanesulfonate	1	592169
23	28.321	Cyclononasiloxane, Hexasiloxane	46	6122178
24	28.396	2H-3,9a-Methano-1-benzoxepin,	11	3520067
25	28.454	2,4-Cyclohexadien-1-one, Indolizine	54	2619597
26	29.249	Benzo[h]quinoline,	43	8068338
27	29.804	1H-Indole-2-carboxylic acid	43	1245970

Table (5): GC-MS analysis of El-Mahmoudia sample area and verified in the NIST 2008 (National Institute of Standard and Technology Library).

Peak no.	RT (min)	Name compounds	Quality	Area (Ab*s)
1	34.301	Silane, trimethyl[5-methyl-2-(1-methylethyl)phenoxy], Tetrasiloxane	43	384617
2	34.383	Tetrasiloxane, decamethyl	43	335256
3	34.698	Methyltris(trimethylsiloxy)silane	37	722582
4	44.86	Propiophenone, 2'-(trimethylsiloxy)	37	611571
5	44.984	Methyltris(trimethylsiloxy)silane	32	639654
6	45.117	Silicic acid, diethyl bis(trimethylsilyl) ester	90	682098
7	47.667	Tetrasiloxane, decamethyl, Benzestrol di-TMS derivative, 1,1,1,3,5,5,5-Heptamethyltrisiloxane	43	11192351

In conclusion, several prior researches have thoroughly examined the detrimental impacts of heavy metals on both human and ecological systems. Elevated concentrations of heavy metal pollutants in water have a detrimental impact on the biological processes of water, such as nutrient recycling and primary nutrient generation. The health of wildlife and people is also impacted by the process of bioaccumulation in the food chain, which leads to the development of metal tolerance in certain creatures and has long-lasting effects.

Moreover, metals can have detrimental ecological effects, such as disrupting interactions between different kinds of freshwater animals and microorganisms. Nevertheless, this discussion will focus on the impact of water pollution caused by heavy metals on plants, aquatic creatures, and people. The toxicity of heavy metals to aquatic plants, animals, and humans is determined by the solubility and bioavailability of the metals, the tolerance of organisms, pH levels, and the presence of other ions that disrupt bioavailability (45).

Metals in water exist as intricate combinations of distinct mineral phases. The consequences on human health are determined by the bioavailability of metals. Multiple researches have investigated how water may be a source of exposure, such as through contact with the skin. The primary determinant of adverse health effects on humans is the concentration or amount of a substance that is taken (46).

Recommendations

Every industry should have its dedicated industrial waste treatment facility to handle its trash. In the same way, urban runoff pounds should be in place to filter out pollutants and reduce the possibility of flooding. The use of hazardous pesticides and herbicides should be replaced with safer alternatives, such as nontoxic alternatives or biological control methods.

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