Journal of Environmental Chemistry and Ecotoxicology Vol. 3(3), pp. 37-44, March 2011
Available online http://www.academicjournals.org/jece
ISSN-2141-226X ©2011 Academic Journals

Full Length Research Paper

Monitoring of basic and acid radicals load in main canal, Giza governorate: A risk to health of consumers

Abd El-Moneim M. R. Afify, Sayed A. Fayed and Emad A. Shalaby*

Biochemistry Department, Faculty of Agriculture, Cairo University, Giza, Egypt, 12613.

Accepted 26 October, 2010

The main canal (Masraf El-Moheet) is one of the largest canals in Giza governorate (Egypt). Due to the extended domestic activities and urbanization as well as the continuous industrial and agricultural growth of the region, water quality is potentially changing and causes fish floating and death. This study was conducted to measure toxic metals concentrations in water samples along the main channel using ICP Spectrometer (iCAP 6000 Series; Thermo Scientific). The most pronounced feature is the highest concentration of Fe, NH_4, Al, Pb and Cr in main canal (35.28, 11.55, 9.318, 0.386 and 0.748 mg L^{-1}, respectively) when compared with World Health Organization, United States Environmental Protection Agency and Egyptian Organization for Standardization and Quality Control. Analysis of variance (ANOVA) of metals levels showed significant difference among the regions. The present results showed that the collected water samples based on the higher levels of metal accumulation could be the first reason for fish floating and death in these regions, in addition to unsafe use for human consumption.

Key words: Water pollution, heavy metals, anions radicals, fish floating, Giza canals.

INTRODUCTION

The poor quality of available water supplies is a major environmental concern and it is one that afflicts the world, including Egypt. Water contamination by point sources of pollution from industrial, domestic and/or agricultural discharge occurs in many parts of Egypt, particularly in the rural areas. Many industries discharge inadequately treated-wastes into waterways network which include irrigation canals and drains. Water degradation from non point sources of pollution, due to the agrochemicals improper management by the farmers, mainly fertilizers and pesticides, is already a serious problem in the Nile Delta Region (Watts and El-Katsha, 1995). Water pollution, if allowed to grow uncontrolled, is likely to cause substantial economic and health ramifications to the country. Within this context, it is estimated that the proportion of urban population in Egypt having access to safe drinking water dropped from 93% in 1982-85 to 82% in 1990-96, and the proportion of the rural population from 61 to 50% while sanitation services were available for only 23% of the urban population and 6% of the rural population (World Bank, 2000). Polluted water related diseases are very frequent in Egypt, accounting for 90,000 deaths each year. Outbreaks of diseases such as cholera, typhoid, and infectious hepatitis have occurred in several provinces because of drinking water pollution. For instance, 10% of the rural population in 1995 was affected by diseases as a result of contamination of surface water with human waste. The contamination of those surface and ground waters could also affect the food chain causing deadly intestinal diseases or poisoning (Watts and El-Katsha, 1995).

Chemicals derived from agricultural activities (pesticides, fertilizer and herbicides) and industrial effluents, such as metals, ultimately find their way into a variety of different water bodies and can produce a range of toxic effects in aquatic organisms, ranging from alterations to a single cell, up to changes in whole populations (Bernet et al., 1999; Marcovecchio et al., 2007; Al-Kahtani, 2009). The accumulation of toxic metals to hazardous levels in aquatic biota has become a problem of increasing concern. Excessive pollution of surface waters could lead to health hazards in man, either

*Corresponding author. E-mail: dremad2009@yahoo.com.

through drinking of water and/or consumption of fish (Mathis and Cummings, 1973). It seems without sense the increasing importance of fish as a source of protein and the interest in understanding the accumulation of heavy metals at the tropic levels of the food chain, extend the focus towards finfish (Obasohan, 2007). Pollution enters fish through five main routes: Via food or non-food particles, gills, oral consumption of water and the skin. On absorption, the pollutant is carried in blood stream to either a storage point or to the liver for transformation and/or storage. Pollutants transformed in the liver may be stored there or excreted in bile or transported to other excretory organs such as gills or kidneys for elimination or stored in fat, which is an extra hepatic tissue (Nussev et al., 2000). The concentration of any pollutant in given tissue therefore depends on its rate of absorption and the dynamic processes associated with its elimination by the fish. Stocks of both freshwater and marine fish within Saudi Arabia are increasingly threatened by aquatic pollution, but no data are available on the extent pollution impacts. Fathi and Al-Kahtani (2009) showed that main canal water had an obvious increase in electrical conductivity, Chemical Oxygen Demand (COD), total alkalinity, nitrates, phosphorus, chloride and potassium. These features indicated pollution with organic wastes, increased salinity and deteriorated oxygenated state.

The effect of exposure of organisms to any potentially toxic substance depends on its concentration as well as exposure time. One of the effects frequently observed by environmental agents is the chemical alteration of the DNA affecting vital processes like DNA duplication and transcription, gene regulation and cell division, and leading cells to pathologic processes and/or cell death (Barberio, 2009).

Potentially toxic metals, resulting from some agriculture and industrial activities are one of the most common environmental contaminants and several have been shown to be mutagenic and/or carcinogenic in both human and animal studies (Egito et al., 2007)

Heavy metal can cause serious health effects with varied symptoms depending on the nature, quantity and exposure time of the metal ingested (Adepoju-Bello and Alabi, 2005; Adepoju-Bello et al., 2009). They produce their toxicity by forming complexes with proteins, in which carboxylic acid (–COOH), amine (–NH2), and thiol (–SH) groups are involved. These modified biological molecules lose their ability to function properly and result in the malfunction or death of the cells. When metals bind to these groups, they inactivate important enzyme systems or affect protein structure, which is linked to the catalytic properties of enzymes. This type of toxin may also cause the formation of radicals which are dangerous chemicals that cause the oxidation of biological molecules.

The most common heavy metals that humans are exposed to are Aluminium, Arsenic, Cadmium, Lead and Mercury. Aluminium has been associated with Alzheimer and Parkinson's disease, senility and presenile dementia. Arsenic exposure can cause among other illness or symptoms, cancer, abdominal pain and skin lesions.

Cadmium exposure produces kidney damage and hypertension. Lead is a commutative poison and a possible human carcinogen (Bakare-Odunola, 2005) while for Mercury, toxicity results in mental disturbance and impairment of speech, hearing, vision and movement (Hammer and Hammer, 2004). In addition, Lead and Mercury may cause the development of autoimmunity in which a person's immune system attacks its own cells. This can lead to joint diseases and ailment of the kidneys, circulatory system and neurons. At higher concentrations, Lead and Mercury can cause irreversible brain damage.

In the present work, heavy metals and other metals accumulation levels as well as acidic radical in water samples were determined from Giza canals to identify the first reason for fish floating or death in this area.

MATERIALS AND METHODS

Sample collection and location

Water samples were randomly collected from 12 sampling sites (from Masraf El Moheete) in 7 different areas: 1-Sugar Company (El-hawamdya, 3 samples), 2- Sewage treatment region (3 samples), 3- Sakara canal (2 samples), 4- Abou Cir canal, 5- Shapramant canal, 6- El maryotia canal, 7- El harania canal. The samples were collected during the month of February 2010. The collected water samples individually were placed in clean bags and immediately taken to the laboratory where they were kept at 4°C in refrigerator until used for analysis.

Sample digestion

For the analysis of total ions (dissolved and suspended), water (200 mL) samples were digested with 5 mL of di-acid mixture (HNO3:HClO4 : 9: 4 ratio) on a hot plate and filtered by Whatman No. 42 filter paper and made up the volume to 50 mL by double distilled water for analysis of 19 ions (APHA, 1995).

Electric conductivity (EC) and pH values of water samples

The pH of water samples was determined using pH-meter with electronic glass electrode (LI 127 of Elico, India) and conductivity (EC) was measured by conductivity-meter (Systronics 304). (Kar et al., 2008).

Analysis of basic radicals

The digested water samples were analyzed for the presence of aluminum, cadmium, chromium, iron, magnesium, manganese, strontium, zinc and lead using the ICP Spectrometer (iCAP 6000 Series; Thermo Scientific). The calibration plot method was used for the analysis (APHA, 1995).

Analysis of acid radicals

The digested water samples were analyzed for the presence of

Figure 1. Map of the study area the arrow (↑) pointes the place of the study.

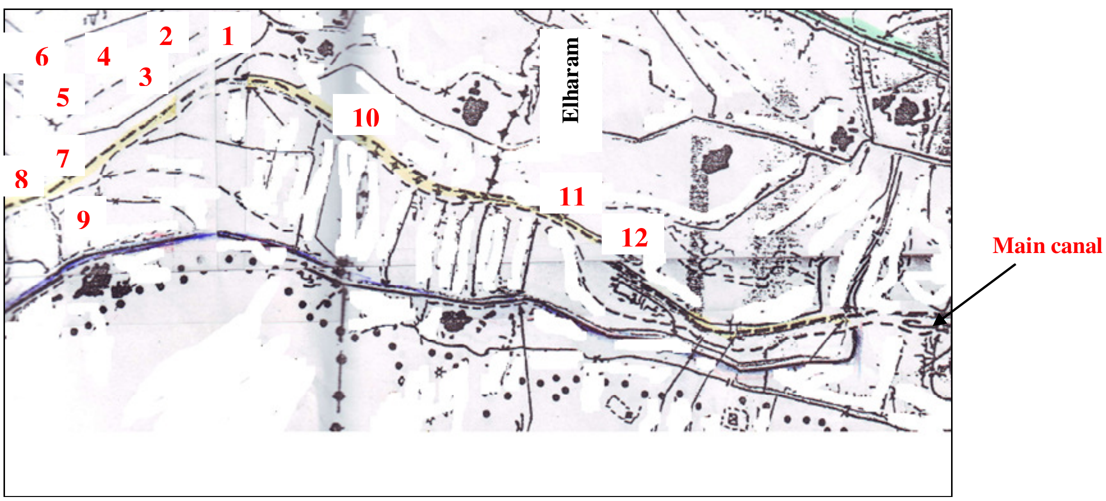

Figure 2. Map of the main canal, Giza governerate**.** 1- Sugar company (El Hawamdya) after treatment; 2- Sugar company (El Hawamdya) before treatmen; 3- outside the wall of sugar company; 4- Sewage treatment station before treatment; 5- Sewage treatment station after treatment; 6- Sample from canal (Sewage treatment station); 7- Sakara canal; 8- Sakara canal station 2; 9- Abou Cir canal.; 10- Shapramant canal; 11- El maryotia canal; 12- El harania.

chloride (calorimetrically and titer metrically) according to Clarke (1950); Phosphorus (colorimeterically) according to El-Merzabani et al. (1977); sulphate was determined accordingto Furniss et al. (1989); nitrate was determined according to Cataldo et al. (1975) and carbonate and bicarbonate were determined according to Jackson (1967).

Statistical analysis

Data were subjected to an analysis of variance, and the means were compared using the Least Significant Difference (LSD) test at the 0.05 level, as recommended by Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Electric conductivity as mmos/cm and pH values of water samples collected from different regions (Figures 1 and 2) on main canal is presented in Table 1. The data show that there is difference in pH values in all regions (ranged

Table 1. The physical properties of water samples collected from main canal at different regions.

Sample no.	Area classification	EC mmos/cm	pH	Color
1	Industrial area	4.186[c]	b7.79[b]	Brown
2	Industrial area	4.65[a]	4.35 [h]	Brown
3	Industrial area	4.30[b]	7.47 [de]	Brown
4	Agricultural area	2.47[e]	7.50 [d]	Light brown
5	Agricultural area	1.93[h]	6.88 [g]	Light brown
6	Agricultural area	1.95[h]	7.50[d]	Light brown
7	Residential area	0.94[i]	7.437[e]	Brown
8	Residential area	2.56[d]	8.10[a]	Light brown
9	Agricultural area	2.25[g]	7.52[cd]	Yellow
10	Agricultural area	0.867[j]	7.32 [f]	Black
11	Residential area	1.946[h]	6.83 [g]	Black
12	Agricultural area	2.33[f]	7.57 [c]	Black
LSD at 0.05		0.05329	0.05329	

Each value is presented as mean of triplet treatments. Values with different superscript letters within the same column are significantly different ($P < 0.05$).

Figure 3. Disaster of the fish floating or death in the main canal, Giza governorate.

from 4.35 and 8.10) but the EC value ranged between 0.867 at region 10 to 4.65 mmos/cm at region 2. The most pronounced feature is the highest values of EC in the first three regions (El-Hawmdya Sugar Company). In addition, the color of the collected samples were ranged from yellow at region 9 to black at region 10, 11 and 12 and these variables in water physical parameter may be due to the amount and kind of contamination from different factories in this area (Figure 3).

The mean concentration of the heavy metals and other ions in main canal in Giza governorate compared with World Health Organization (WHO, 1985), United States Environmental Protection Agency (USEPA, 1986) and Egyptian Organization for Standardization and Quality Control (EOSQC, 1991) allowable limits are presented in Tables 2 and 3. The data in Table 3, show that the concentration of cadmium in water ranged between 0.002 mg L^{-1} at region 5, 6, 7, 8, 10 and 12 to 0.012 mg L^{-1} at region 3, but the concentration of copper in water ranged between 1.218 mg L^{-1} at region 10 to 9.22 mg L^{-1} at region 3. However, aluminum, lead, iron and magnesium concentrations at region 1 were found to be much higher

Table 2. The acid radical content (as µg/ml) of water samples collected from main canal at different regions.

Sample no.	S^{--}	Cl^{-}	SO_4^{--}	NO_3^{-}	$CO3^{--}$	HCO_3^{-}	PO_4^{---}	CN^{-}
1	534^{e}	456.41^{cd}	1602.2^{c}	11.431^{d}	ND	1611.35^{a}	52.4^{b}	ND
2	469.2^{d}	521.6^{a}	1407.5^{d}	26.96^{a}	ND	0.0^{j}	57.8^{a}	ND
3	251.4^{h}	476.6^{b}	754.3^{f}	13.27^{c}	ND	1475.25^{b}	51.8^{b}	ND
4	236.96^{j}	245.06^{h}	710.85^{f}	7.10^{g}	ND	1068.3^{c}	25.6^{d}	ND
5	235.44^{k}	269.9^{g}	706.28^{f}	3.84^{i}	ND	577.13^{e}	53.2^{b}	ND
6	293.52^{e}	159.6^{i}	880.6^{e}	4.64^{h}	ND	779.06^{d}	53.2^{b}	ND
7	275.56^{f}	89.9^{j}	826.7^{e}	3.67^{i}	ND	347.26^{g}	30.5^{cd}	ND
8	239.24^{i}	472.1^{bc}	717.74^{f}	4.64^{h}	ND	347.53^{g}	36.2^{c}	ND
9	788.4^{b}	409.19^{e}	2365.4^{b}	9.55^{e}	ND	344.43^{h}	28.03^{d}	ND
10	858^{a}	101.2^{j}	2574.2^{a}	3.29^{i}	ND	339.56^{h}	24.2^{d}	ND
11	260.6^{g}	308.01^{f}	782^{f}	22.10^{b}	ND	201.62^{i}	32.3^{c}	ND
12	232.68^{l}	447.4^{d}	698.04^{fg}	7.63^{g}	ND	388.1^{f}	32.7^{c}	ND
WHO	50	100	250	50	35	80	0.4	0.0
USEPA	40	100	250	50	50	80	0.4	0.0
EOSQC	40	400	300	40	50	77	0.4	0.0
LSD at 0.05	0.255	18.61	50.869	0.436	NS	45.635	11.4352	NS

Each value is presented as mean of triplet treatments, means within each row with different letters (a-l) differ significantly at P # 0.05 according to Duncan's multiple range test, WHO: World health organization; USEPA: United States environmental protection agency; EOSQC: Egyptian Organization for standardization and quality control.

(9.318, 0.386, 35.28 and 105.3 mg L^{-1} respectively) than other eleven regions. On the other hand, cadmium, chromium and copper were found to be much higher concentration on region 3 (0.012, 0.748 and 9.22 mg L^{-1}, respectively). But strontium and zinc were found to be much higher on region 4 (4.676 and 6.18 mg L^{-1}, respectively).

The most pronounced feature is the highest concentration of iron, ammonia, aluminum, lead and chromium in main canal (35.28, 11.55, 9.318, 0.386 and 0.748 mg L^{-1}, respectively) in comparison to other metals. Analysis of variance (ANOVA) of metals levels showed significant difference among the regions.

The levels of heavy metals recorded in water in this study were generally high, when compared to World Health Organization (WHO, 1985), United States Environmental Protection Agency (USEPA, 1986), and Egyptian Organization for Standardization and Quality Control (EOSQC, 1991) recommended levels in water. The high level of these elements at the mentioned regions could be attributed to discharge of either treated sewage water or re-use drainage water on the main canal in Giza governorate. The data in Table 3 showed that most determined heavy metals had the highest value in the first three regions (industrial area) and these results indicated El-Hawmdya Sugar Company to be one of the main reasons responsible for realizing of heavy metals in the main canals and may lead to the decreasing of available oxygen in these regions and cause fish floating and death.

The crucial roles of zinc and copper in several enzymatic processes are classified as highly toxic metals by Hellawell (1986) and are bio-accumulated in aquatic organisms. On the other hand, organs of aquatic animals may accumulate copper when exposed to toxic concentrations (Mazon et al., 2002), which can lead to redox reactions generating free radicals and, therefore, may cause biochemical and morphological alterations (Monteiro et al., 2005). In addition, Pb++ residues could result in hematological, gastrointestinal and neurological dysfunction in animals. Severe or prolonged exposure to Pb++ may also cause chronic nephropathy, hypertension and reproductive impairment. Pb++ inhibits enzymes, alters cellular calcium metabolism and slows nerve conduction (Lockitch, 1993). In parallel, cadmium is a widespread environmental pollutant that is highly toxic and is considered to have no biological function (Hallenbeck, 1984). It causes severe membrane integrity damage with a consequent loss of membrane-bound enzyme activity which can result in cell death (Younes and Siegers, 1984). This and other nonessential metals have been reported to cause anemia both in mammals (Kostic et al., 1993) and in fish (Gwozdzinski et al. 1992; Al-Kahtani, 2009).

The results of acid radicals analysis of polluted water are shown in Table 2. The data reported that, S-- and SO4-- concentration on region 10 were found to be much higher (858 and 2574.2 mg L^{-1}, respectively) than other region but Cl- and HCO3- concentration were found to be much higher (521, 6 and 1611.35 mg L^{-1} at regions 1 and 2 respectively). On the other hand, CO3-- and CN- are non detectable (ND) in samples analysis. The data

Table 3. The basic radical content (as µg/ml) of water samples collected from main canal at different stations.

Sample no.	Al^{+++}	Cd^{++}	Cr^{+++}	Cu^{++}	Pb^{++}	Fe^{++}	Mg^{++}	Mn^{++}	Sr^{+++}	Zn^{++}	NH_4^{+}
1	9.318 ^{a}	0.01 ^{b}	0.498 ^{b}	2.638 ^{c}	0.386 ^{a}	35.28 ^{a}	105.3 ^{a}	1.42 d^{e}	1.666 ^{d}	2.234 ^{e}	4.9^{d}
2	3.16 b^{cd}	0.004 ^{b}	0.408 ^{b}	3.17 ^{b}	0.132 ^{cde}	12.383 ^{bcd}	92.7 ^{c}	0.338 ^{i}	0.984 ^{g}	1.568 ^{gh}	11.5^{a}
3	2.455 b^{cd}	0.012 ^{a}	0.748 ^{a}	9.22 ^{a}	0.378 ^{b}	30.9 ^{a}	95.34 ^{b}	1.306 ^{e}	1.486 ^{e}	2.46 ^{cd}	5.68^{c}
4	2.044 ^{cd}	0.004 ^{b}	0.28 ^{c}	1.434 ^{ef}	0.142 ^{cde}	14.554 ^{bc}	65.24 ^{d}	4.292 ^{a}	4.676 ^{a}	6.18 ^{a}	3.04^{g}
5	2.278 ^{bcd}	0.002 ^{b}	0.234 ^{c}	1.462 ^{def}	0.13 ^{cde}	9.214 ^{bcd}	38.54 ^{f}	2.694 ^{b}	2.998 ^{b}	3.764 ^{b}	1.65^{i}
6	4.584 ^{b}	0.002 ^{b}	0.25 ^{c}	1.274 ^{gh}	0.174 ^{c}	10.218 ^{bcd}	35.46 ^{h}	1.942 ^{c}	2.1 ^{c}	2.606 ^{c}	1.98^{h}
7	1.472 ^{cd}	0.002 ^{b}	0.222 ^{c}	1.448 ^{de}	0.122 ^{de}	5.96 ^{bcd}	26.08 ^{k}	1.334 ^{e}	1.59 ^{d}	2.544 ^{cd}	1.57^{j}
8	0.964 ^{bc}	0.002 ^{b}	0.236 ^{c}	1.342 ^{fg}	0.168 ^{cd}	4.09 ^{cd}	37.06 ^{g}	0.9 ^{f}	1.518 ^{e}	1.352 ^{h}	1.98^{h}
9	1.328 ^{d}	0.004 ^{b}	0.182 ^{cd}	1.358 ^{efg}	0.144 ^{cde}	3.436 ^{d}	32.26 ^{i}	0.652 ^{g}	1.232 ^{f}	1.616 ^{g}	4.09^{e}
10	1.796 ^{cd}	0.002 ^{b}	0.252 ^{c}	1.218 ^{h}	0.106 ^{e}	3.272 ^{d}	21.24 ^{l}	0.624 ^{h}	0.912 ^{g}	1.694 ^{fg}	1.41^{k}
11	2.456 ^{bcd}	0.006 ^{b}	0.24 ^{c}	1.534 ^{d}	0.172 ^{cd}	11.396 ^{bcd}	57.5 ^{e}2	1.484 ^{d}	1.634 ^{d}	2.396 ^{de}	9.5^{b}
12	2.232 ^{cd}	0.002 ^{b}	0.108 ^{d}	1.442 ^{dfg}	0.082 ^{f}	5.93 ^{bcd}	26.32 ^{j}	0.344 ^{i}	0.806 ^{h}	1.89 ^{f}	3.27^{f}
WHO	0.05	0.05	0.05	1.0	0.05	1.0	50	0.01	0.001	5.0	0.1^{m}
USEPA	0.05	0.01	0.05	1.0	0.05	1.0	50	0.05	0.002	1.0	0.1^{m}
EOSQC	0.05	0.005	0.05	1.0	0.1	0.3	100	1.0	0.001	10	0.5^{l}
LSD at 0.05	2.443	0.0533	0.1066	0.1192	0.0532	11.24	0.1685	0.141	0.0923	0.1994	0.0111

Each value is presented as mean of triplet treatments, means within each row with different letters (a-l) differ significantly at P # 0.05 according to Duncan's multiple range test, WHO: World Health organization; USEPA: United states environmental protection agency; EOSQC: Egyptian organization for standardization and quality control.

Table 4. Summary statistics of acid radical's analysis.

	S^{--}	Cl^{-}	SO_4^{--}	NO_3^{-}	$CO3^{--}$	HCO_3^{-}	PO_4^{---}	CN^{-}
Number of samples	12	12	12	12	12	12	12	12
Number with elements detected	12	12	12	12	0.0	11	12	0.0
% detected	100	100	100	100	0.0	91.66	100	0.0
Minimum concentration detected (mg/l)	232.68	89.9	710.85	3.29	-	0.0	24.2	-
Maximum concentration detected (mg/l)	858	521.6	2574.2	26.96	-	1611.35	57.8	-
WHO Maximum Contaminant Level (MCL)	50	100	250	50	35	80	0.4	0.0
Number above MCL	12	11	12	0.0	0.0	12	12	-
% above MCL	100	91.66	100	0.0	0.0	100	100	-

in Table 2 confirmed that the general trend of anions concentration was highly in the first three regions when compared with most 12 regions and these results are correlated with the results obtained with cations concentrations.

The summary of statistical analysis of acid and basic radicals are shown in Tables 4 and 5 and the results illustrated that, most of collected samples had ion concentration above WHO maximum contaminant level (MCL) and this causes dangerous state for using this water in all consumption fields (industrial, agriculture) and its

Table 5. Summary statistics of basic radical analysis.

	Al+++	Cd++	Cr+++	Cu++	Pb++	Fe++	Mg++	Mn++	Sr+++	Zn++	NH4+
Number of samples	12	12	12	12	12	12	12	12	12	12	12
Number with elements detected	12	12	12	12	12	12	12	12	12	12	12
% detected	100	100	100	100	100	100	100	100	100	100	100
Minimum concentration detected (mg/l)	1.328	0.002	0.108	1.218	0.082	3.272	21.24	0.338	0.806	1.568	1.41
Maximum concentration detected (mg/l)	9.318	0.012	0.748	9.22	0.386	35.28	105.3	4.292	4.676	6.18	11.5
WHO M aximum Contaminant Level (MCL)	0.05	0.05	0.05	1.0	0.05	1.0	50	0.01	0.001	5.0	0.1
Number above MCL	12	0.0	12	12	12	12	5.0	12	12	1.0	12
% above MCL	100	0.0	100	100	100	100	41.66	100	100	8.33	100

living organisms (e.g. fish). These results are in harmony with the results obtained by Momodu and Anyakora (2010) who reported that high concentration of heavy metals (above WHO) suggests a significant risk to this population, given the toxicity of these metals and the fact that for many, hand dug wells and bore holes are the only sources of their water supply in this environment.

Overall, all samples contained detectable amounts of all the heavy metals studied and in some cases the levels were above WHO specified Maximum Contaminant Level with focused on samples 1, 2 and 3. Eight samples contain high levels of these metals.

Conclusion

The present results showed that, the collected water samples especially from the first three regions (El-Hawmdya Sugar Company) based on the higher levels of metal accumulation could be the first reason for fish death or floating in these regions.

REFERENCES

Adepoju-Bello AA, Alabi OM (2005). Heavy metals: A review. The Nig J Pharm., 37: 41-45

Adepoju-Bello AA, Ojomolade OO, Ayoola GA, Coker HAB (2009). Quantitative analysis of some toxic metals in domestic water obtained from Lagos metropolis. Nig. J. Pharm., 42 (1): 57-60.

Al-Kahtani MA (2009). Accumulation of Heavy Metals in Tilapia Fish (Oreochromis niloticus) from Al-Khadoud Spring, Al-Hassa, Saudi Arabia. Am. J. Appl. Sci., 6 (12): 2024-2029.

APHA (1995). Standard methods for the examination of water and waste water, 19th. Ed, American Public Health Association, American Water Works Association and Water Environment Federation, Washington, DC.

Bakare-Odunola MT (2005). Determination of some metallic impurities present in soft drinks marketed in Nigeria. Nig. J. Pharm., 4(1): 51-54.

Barberio A (2009). Cytotoxic and genotoxic effects in root meristem of Allium cepa exposed to water of the river Paraíba do Sul - São Paulo state - Tremembé and regions. PhD thesis, University of Campinas - Unicamp, Campinas - São Paulo, Brazil.pp.54-62

Bernet D, Schmidt H, Meier W, Burkhardt- Hol P, Wahli T (1999). Histopathology in fish: Proposal for a protocol to assess DOI: 10.1046/j.1365- 2761.1999.00134.x aquatic pollution. J. Fish Dis., 22: 25-34.

Cataldo DA, Haroon M, Schrader LE, Youngs VL (1975). Rapid calometric determination of nitrate in plant tissues by nitration of salicylic acid. Common Soil Sci. Plant Ana., 6: 71-80.

Clarke FE (1950). Determination of chloride in water improved colorimeteric and titrimetric methods. Anal. Chem., 22(4): 553-555.

Egito LCM, Medeiros MG, Medeiros SRB, Agnez-Lima LF (2007). Cytotoxic and genotoxic potential of surface water from the Pitimbú river, northeastern/RN Brazil. Genet. Mol. Biol., 30: 435-441.

Egyptian Organization for standardization and quality control (1991). Frozen fish, Cairo, Egypt.

El-Merzabani MM, El-Aaser AA, Zakhary NI (1977). Determination of inorganic phosphorus in serum. J. Clin. Chem. Clin. Biochemist., 15: 715-718.

Fathi AA, Al-Kahtani M (2009). Water quality and planktonic communities in Al-khadoud spring, Al-Hassa, Saudi Arabia. Am. J. Environ. Sci., 5: 434-443.

Furniss BS, Hannaford AJ, Rogers V, Smith PWG, Tatchell AR (1989). Vogels textbook of practical Organic Chemistry, pp. 831-832.

Gwozdzinski K, Roche H, Peres G (1992). The comparison of the effects of heavy metal ions on the antioxidant enzyme activities in human and fish Dicentrarchus labrax erythrocytes. Comput. PMID: 1358529 Biochem. Physiol. C., 102: 57-60.

Hellawell JM (1986). Biological Indicators of Freshwater Pollution and Environmental Management. Elsevier Applied Science Publishers Ltd., London and New York, ISBN: 10- 1851660011, p. 546.

Jackson ML (1967). Soil chemical analysis; Hall of India Pvt. Ltd., New Delhi, p. 498.

Kar D, Sur P, Mandal SK, Saha T, Kole RK (2008). Assessment of heavy metal pollution in surface water. Int. J. Environ. Sci. Tech., 5

(1): 119-124.

Kostic MM, Ognjanovic B, Dimitrijevic S, Zikic, RV, Stajn A (1993). Cadmium-induced changes of antioxidant and metabolic status in red cells of rats: In vivo effects. Eur. J. Haematol., 51: 86-92.

Lockitch G (1993). Perspectives on lead toxicity. Clin. Biochem., 26: 371-381.

Hallenbeck WH (1984). Human health effects of exposure to cadmium. Cell. Mol. Life Sci., 40: 136-142. DOI: 10.1007/BF01963576.

Hammer MJ, Hammer Jr MJ (2004). Water Quality. In: Water and W aste W ater Technology. 5th Edn. New Jersey: Prentice-Hall, p. 139-159.

Marcovecchio JE, Botte, SE, Freije RH (2007). Heavy Metals, Major Metals, Trace Elements. In: Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press, pp.275-311.

Mathis BJ, Cummings TF (1973). Selected metals in sediments, water and biota of the Illinois River. J. Water Poll. Cont. Trop., 45: 1573-1583. PMID: 4720140.

Mazon AF, Cerqueira CCC, Fernandes MN (2002). Gill cellular changes induced by copper exposure in the South American tropical freshwater fish Prochilodus scrofa. Environ. Res., 88: 52-63.

Momodu MA, Anyakora CA (2010). Heavy Metal Contamination of Ground Water: The Surulere Case Study. Res. J. Environ. Earth Sci., 2(1): 39-43.

Monteiro SM, Mancera JM, Fonta Dnhas- Fernandes A, Sousa M (2005). Copper induced alterations of biochemical parameters in the gill and plasma of Oreochromis niloticus. Comput. Biochem. Physiol. C., 141: 375-383. DOI: 10.1016/j.cbpc.2005.08.002.

Nussev G, Van Vuren, JHJ, Du Preez HH (2000). Bioaccumulation of chromium, manganese, nickel and lead in the tissues of the moggel, *Labeo umbratus* (Cyprinidae), from Witbank Dam, Mpumalanga. Water SA, 26: 269-284.

Obasohan EE (2007). Heavy metals concentrations in the offal, gill, muscle and liver of a freshwater mudfish (Parachanna obscura) from Ogba River, Benin city, Nigeria. Afr. J. Biotechnol., 6: 2620-2627. http://www.bioline.org.br/pdf?jb07468.

Snedecor GW, Cochran WG. (1982). Statistical Methods. The Iowa State Univ. Press., Ames., Iowa, USA, p.507.

United States Environmental Protection Agency (USEPA), 1986. Quality Criteria for Water. EPA- 440/5-86-001, Office of Water Regulations and Standards, Washington DC., USA.

Watts Sj, El-Katsha S (1995) Schistosomiasis control through rural health units. World health forum, 16: 252-254.

World Bank (2000). World development report. Investing in health. New york, Oxford University press, pp. 25-27.

World Health Organization (WHO) (1985). Guidelines for Drinking Water Quality (Recommendations). WHO, Geneva, ISBN: 92-4- 154696-4: 130.

Younes M, Siegers CP (1984). Interrelation between lipid peroxidation and other hepatotoxic events. DOI: 10.1016/0006-2952(84)90564-1. Biochem. Pharmacol., 33: 2001-2003.