Original Article

The Prospective Toxic Effects of Some Heavy Metals Overload in Surface Drinking Water of Dakahlia Governorate, Egypt

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Abstract

Background: The concentration of heavy metals in drinking water is very important.

Objectives: To to evaluate the chemistry of some heavy metals in surface drinking water of Dakahlia Governorate, Egypt.

Methods: 51 surface drinking water samples were collected from the main surface water stations and compact units in October 2009 and analyzed chemically. 26 water samples were analyzed by atomic absorption spectrophotometer for iron, manganese, lead, nickel, chromium, zinc, copper, cobalt, aluminum, and cadmium concentrations.

Results: Aluminum concentration was slightly high in water sample of Bosat network. Cadmium concentration in samples of up-streams of shark and Mit-Khamis stations, networks of Mit-Antar, Demera, Bosat, Bilqas, El-satamony, El-Gamalia, Mit-asim and Bilqas station exceeded the permissible limits of Egyptian Ministry of Health (EMH, 2007) and World Health Organization (WHO, 2008). The nickel concentration in the network samples taken from Shoha, Bosat and El-Gamalia as well as up-stream of Bosat station exceeded the permissible limits. Also, lead concentrations of the network samples of Shoha, Mit-Antar, Demera and Nabaru exceeded the permissible limits.

Conclusion: Regular chemical analysis of surface drinking water is required. Since these heavy metals are most likely originate from steel, plastics and batteries industries working in the region, we believe that activities of these industries must be stopped or at least limited in urban zones.

Keywords: Surface water; Aluminum; Cadmium; nickel; Metals, Heavy; Elements

Introduction

Dakahlia Governorate is a region in North of Egypt. The surface water in Dakahlia Governorate is mainly from the River Nile flowing in Damietta branch and its distributaries irrigation canals. Abd el-Daiem and Ramsussen reported that at Mansoura, the surface water level in the Nile branch is +1.8 m, while it is about +4 m in the nearby water wells, where the river is recharged by groundwater and becomes effluent stream in that sector and the Nile branch down stream of Mansoura behaves as a drain.[1] Rainwater collects impurities while passing through the air. Streams and rivers collect impurities from surface run-off and through the discharge of sewage, industrial and agriculture effluents. These are carried to the

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Table 1: Chemical analysis in ppm (mg/L) of water samples taken from the main surface drinking water stations

No	District/sample name	pH	EC μm/cm at 25 °C	TDS ppm	TH ppm	Cl_2 ppm	Cl^- ppm	SO_4^{2-} ppm	Alkal. ppm	Al^{3+} ppm
Permissible limit of WHO (2008)		**6.5–8**		**1000**	**500**	**5**	**250**	**250**		**0.1**
Permissible limit of EMH (2007)		**6.5–8.5**		**1000**	**500**	**5**	**250**	**250**		**0.2**
I	El-Mansoura district									
	Up-stream of shark station	8.18	414	269.1	136	—	22.7	67.31	155	—
	Main station	7.75	444	288.6	144	0.66	35.45	75	150	0.03
	Network	7.85	450	292.5	140	0.52	34.75	81.73	140	0.04
	Up-stream of Mit-khamis station	8.05	430	279	145	—	25.53	66	160	—
	Main station	7.69	443	288	136	1.56	34.73	99	145	0.08
	Network	7.6	446	290	137	1.5	34.03	80	140	0.03
II	Talkha district									
	Up-stream of Talkha station	8.0	427	277.5	137	—	24.11	34	151	—
	Main station	7.68	425	276.3	144	1.95	35.45	60	146	0.10
	Network	7.75	436	283.4	136	1.3	34.03	46	142	0.05
III	Dekernis district									
	Up-stream of Mit-Faris station	7.99	426	276.9	140	—	29.8	43.3	160	—
	Main station	7.65	428	278.2	132	0.53	32.6	90	135	0.09
	Network	7.72	461	269.6	142	0.33	34.03	78.85	150	0.08
IV	Sherbin district									
	Up-stream of Sherbin station	8.05	440	286	144	—	31.2	39	170	—
	Main station	7.74	438	284.7	137	1.5	34.03	56	155	0.10
	Network	7.41	433	281.5	141	1.35	33.33	44	152	0.05
	Up-stream of Bosat station	8.23	448	291.2	144	—	35.45	76.93	165	—
	Main station	7.73	435	282.2	128	0.6	36.9	75	150	0.10
	Network	7.8	460	299	140	0.33	38.28	60.57	175	0.11
V	Bilqas district									
	Up-stream of Bilqas station	8.05	462	300.3	142	—	34.03	33.46	160	—
	Main station	7.76	477	310.1	144	0.64	35.45	96.15	155	0.05
	Network	7.81	475	308.7	140	0.41	38.3	86.54	150	0.08

Continued

Table 1: Chemical analysis in ppm (mg/L) of water samples taken from the main surface drinking water stations

No	District/sample name	pH	EC µm/cm at 25 °C	TDS ppm	TH ppm	Cl_2 ppm	Cl^- ppm	SO_4^{2-} ppm	Alkal. ppm	Al^{3+} ppm
Permissible limit of WHO (2008)		**6.5–8**		**1000**	**500**	**5**	**250**	**250**		**0.1**
Permissible limit of EMH (2007)		**6.5–8.5**		**1000**	**500**	**5**	**250**	**250**		**0.2**
VI	El-Gamalia district									
	Up-stream of El-Gamalia station	8.14	428	278.2	134	—	31.2	73.07	150	—
	Main station	7.73	435	282.7	134	0.57	35.45	79.81	125	0.05
	Network	7.62	438	284.7	130	0.36	32.6	86.5	150	0.06
VII	El-Sinbillawin district									
	Up-stream of El-Sinbillawin station	7.15	420	270	134	—	30.1	71	138	—
	Main station	7.35	430	275	135	0.76	36.1	76	120	0.07
	Network	7.12	434	280	130	0.32	32.1	85	144	0.04
VIII	El-Manzala district									
	Up-stream of El-Manzala station	8.11	377	245	140	—	21	32	145	0.01
	Main station	7.45	390	253	124	0.08	20	35	130	0.05
	Network	7.75	393	255	136	0.18	33	53	151	0.06

ppm: Part per million = mg/L, EC: Electrical conductivity µm/cm: µmohs/cm, TDS: Total dissolved salts, TH: Total hardness, Cl_2: Chlorine, Cl^-: Chloride, SO_4^{2-}: Sulfate, Alkal: Alkalinity

rivers, lakes or reservoirs that supply our drinking water.[2] Cadmium (Cd), copper (Cu), cobalt (Co), chromium (Cr), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn) are toxigenic consistently found as contaminants in human drinking water supplies in many areas around the world.[3]

We conducted this study to evaluate the chemistry of surface drinking water with special emphasis on the concentrations of some heavy metals; iron (Fe), Mn, Pb, Ni, Cr, Zn, Cu, Co and Cd and their toxic impacts on human health.

Materials and Methods

Fifty-one surface drinking water samples were taken from the main station (n=30) and compact units (n=21) in Dakahlia Governorate in October 2009. All samples were collected in 2-L polyethylene bottles for the chemical analysis. The parameters, pH, electrical conductivity (EC) and total dissolved salts (TDS) were measured in the field.

The pH was measured by a pH meter (HI 8424 microcomputer, Hanna instruments). TDS and EC were measured using conductivity/TDS-meter (ESD, Engineered Systems & Design). The 51 water samples were subjected to chemical analysis according to the procedure described in the standard method for the examination of water and wastewater.[4] Twenty-six water samples were subjected for measuring levels of Fe, Mn, Pb, Ni, Cr, Zn, Cu, Co and Cd by atomic absorption spectrophotometer (AAS) (Buck Scientific Company, USA). Measurements of each metal level were carried out in duplicate with the suitable parameters (wavelength, concentration ranges and detection limit).

Results

Tables 1 and 2 show that the measured pH values were within the permissible limits of Egyptian Ministry Health (EMH) permissible limits,[5] however they exceed

Table 2: Results of chemical analysis in ppm of the compact units

No	District/sample name	pH	EC µm/cm at 25 °C	TDS ppm	TH ppm	Cl_2 ppm	Cl^- ppm	SO_4^{2-} ppm	Alkal. ppm	Al^{3+} ppm
I	El-Mansoura district									
	Awish el-hagar	7.53	486	315.9	150	0.4	35	43	148	0.03
	Mahalet damana	7.82	420	273	126	0.28	32	52	136	0.02
	Shoha	7.7	371	241	130	0.12	30	44	131	0.02
	El-Rydania	7.77	410	266	130	0.21	40	56	143	0.02
II	Talkha district									
	Mit-antar	7.46	445	298.5	145	1.5	34.03	65	156	0.06
	Mit- elkorama	7.63	486	315.9	150	0.5	31	67	140	0.01
	Demera	7.74	468	304.2	130	0.45	35	46	120	0.03
III	Nabaru district									
	Nabaru	7.67	480	312	140	0.71	50	60	145	0.06
IV	Sherbin district									
	Ras el-khalig	7.72	498	323.7	140	0.6	46	57	133	0.04
V	Bilqas district									
	El-satamony	7.99	385	256	135	0.4	30	36	141	0.04
	Basindela	7.46	410	266.5	135	0.15	30	62	130	0.01
VI	Aga district									
	Nawasa	7.53	398	259	130	0.12	21	30	140	0.01

Continued

Table 2: Results of chemical analysis in ppm of the compact units

No	District/sample name	pH	EC µm/cm at 25 °C	TDS ppm	TH ppm	Cl_2 ppm	Cl^- ppm	SO_4^{2-} ppm	Alkal. ppm	Al^{3+} ppm
VII	El-Manzala district									
	El-aziza	7.79	379	246	140	0.1	28	45	145	—
	El-Mawaged	7.44	375	243	132	0.48	30	45	140	0.02
VIII	Mit-Salsil district									
	Mit-Salsil	7.9	447	290.5	140	0.66	34	57	180	0.04
IX	El-Sinbillawin district									
	Barqin	7.73	359	233	135	0.4	30	45	140	0.03
X	Temy el-amdid district									
	Temy el-amdid	7.76	454	295.1	160	0.43	38	51	150	0.01
	Abo-dawoud	8.01	432	280.8	146	0.3	36	42	150	0.01
XI	Minyet el-nasr district									
	Minyet el-nasr	7.5	431	281.2	130	0.8	30	47	136	0.06
	Mit-asim	7.65	360	234	132	0.08	30	35	135	0.03
	Brembal	7.65	410	266.5	135	0.3	43	38	141	0.02

ppm: Part per million = mg/L, EC: Electrical conductivity, µm/cm: µmohs / cm, TDS: Total dissolved salts, TH: Total hardness, Cl_2: Chlorine, Cl^-: Chloride, SO_4^{2-}: Sulfate, Alkal: alkalinity

the permissible limits of WHO[6] for samples of up-streams of shark, Mit-khamis, sherbin, Bosat, Bilqas, El-Gamalia, El-Manzala stations and Abo-dawoud compact unit. Water Al concentrations were within the permissible limits of EMH,[5] however they equal to and/or exceeded the permissible limits of WHO[6] for samples of Talkha, Sherbin, Bosat stations and network of Bosat station, respectively. Other measured parameters were within the permissible limits. Table 3 shows the values of detected heavy metals, Fe, Mn, Pb, Ni, Cr, Zn, Cu, Co and Cd in surface water samples. The concentration of Cd exceeded the permissible limits of EMH[5] and WHO[6] in the samples of up-streams of shark and Mit-Khamis stations, networks of Mit-Antar, Demera, Bosat, Bilqas, El-satamony, El-Gamalia, Mit-asim and Bilqas station. The concentration of Ni was more than the permissible limits of EMH[5] and WHO[6] in the network samples of Shoha, Bosat and El-Gamalia as well as up-stream of Bosat station. Lead concentrations in the network water samples of Shoha, Mit-Antar, Demera and Nabaru exceeded the permissible limits of EMH[5] and WHO[6].

Discussion

An estimate of Witt, based on WHO reports suggests that 80% of all human illness in the developing countries is associated with polluted water.[7]

Table 3: Results of some heavy metals in ppm of (up-stream, main station and network) samples

No	District/sample name	Cd	Cu	Zn	Cr	Ni	Pb	Mn	Fe	Co
Permissible limit of WHO (2008)		**0.003**	**2.0**	**3.0**	**0.05**	**0.07**	**0.01**	**0.4**	**0.3**	**0.05**
Permissible limit of EMH (2007)		**0.003**	**2.0**	**3.0.**	**0.05**	**0.02.**	**0.01**	**0.4**	**0.3**	**0.05**
I	El-Mansoura district									
	Up-stream of shark station	0.004	0.0	0.0	0.004	0.011	0.001	0.0	0.0	0.002
	Main shark station	0.002	0.0	0.0	0.002	0.008	0.001	0.0	0.0	0.002
	Up-stream of Mit-khamis station	0.006	0.0	0.1	0.004	0.006	0.003	0.0	0.01	0.001
	Network of Mit-khamis station	0.003	0.0	0.0	0.001	0.003	0.0	0.0	0.0	0.001
	Network of Mahalet damana	0.001	0.0	0.0	0.005	0.006	0.002	0.0	0.0	0.001
	Shoha Station	0.0	0.0	0.1	0.008	0.009	0.008	0.01	0.01	0.0
	Network of Shoha	0.0	0.0	0.1	0.008	0.022	0.016	0.01	0.02	0.0
	Network of El-Rydania	0.001	0.0	0.0	0.005	0.002	0.0	0.0	0.0	0.001
II	Talkha district									
	Network of Mit-antar	0.011	0.0	0.0	0.008	0.013	0.033	0.0	0.0	0.0
	Network of Demera	0.032	0.0	0.0	0.003	0.007	0.025	0.0	0.0	0.004
III	Dekernis district									
	Network of Mit-Faris station	0.0	0.0	0.0	0.001	0.011	0.003	0.0	0.0	0.001
IV	Sherbin district									
	Network of Sherbin station	0.001	0.0	0.0	0.006	0.008	0.002	0.0	0.0	0.001
	Up-stream of Bosat station	0.001	0.0	0.0	0.003	0.021	0.0	0.0	0.0	0.001
	Network of Bosat station	0.005	0.0	0.0	0.003	0.022	0.0	0.0	0.0	0.001
V	Bilqas district									
	Main station of Bilqas	0.005	0.0	0.0	0.001	0.009	0.0	0.0	0.0	0.001
	Network of Bilqas station	0.007	0.0	0.0	0.005	0.005	0.0	0.0	0.0	0.001
	Network of El-satamony	0.007	0.0	0.0	0.0	0.010	0.003	0.0	0.0	0.002

Continued

Table 3: Results of some heavy metals in ppm of (up-stream, main station and network) samples

No	District/sample name	Cd	Cu	Zn	Cr	Ni	Pb	Mn	Fe	Co
Permissible limit of WHO (2008)		**0.003**	**2.0**	**3.0**	**0.05**	**0.07**	**0.01**	**0.4**	**0.3**	**0.05**
Permissible limit of EMH (2007)		**0.003**	**2.0**	**3.0**	**0.05**	**0.07**	**0.01**	**0.4**	**0.3**	**0.05**
VI	El-Gamalia district									
	Network of El-Gamalia station	0.010	0.0	0.0	0.001	0.021	0.002	0.0	0.0	0.001
VII	El-Sinbillawin district									
	Network of El-Sinbillawin station	0.002	0.0	0.0	0.0	0.008	0.004	0.0	0.0	0.002
VIII	El-Manzala district									
	Network of El-Manzala station	0.003	0.0	0.0	0.001	0.009	0.003	0.0	0.02	0.002
	Network of El-Mawaged	0.002	0.0	0.01	0.003	0.008	0.0	0.0	0.01	0.001
IX	Nabaru district									
	Network of Nabaru	0.001	0.0	0.0	0.004	0.006	0.038	0.0	0.0	0.0
X	Temy el-amdid district									
	Network of Abo-dawoud	0.003	0.0	0.0	0.003	0.008	0.001	0.0	0.01	0.0
XI	Minyet el-nasr district									
	Network of Mit-asim	0.005	0.0	0.0	0.0	0.018	0.003	0.0	0.01	0.001
	Network of Brembal	0.001	0.0	0.002	0.0	0.005	0.0	0.0	0.0	0.001
XII	Aga district									
	Network of Nawasa	0.001	0.0	0.0	0.001	0.001	0.004	0.0	0.0	0.015

The pH values play an important role in the interaction between heavy metals and many parameters. Toxicity with heavy metals can increase with basic pH values. The abnormality observed in water Al concentrations in the region is probably attributed to addition of excessive Al-alum in these locations. There are many health problems reported in association with aluminum in water. For example, senile dementia is associated with high concentration of Al in water.[8] Water with high concentration of Al cannot be used for hemodialysis too.[8] Concerning on the heavy metals which have overload concentrations in the water samples and their environmental impact on human health.

Primarily, Cd is found in surface water as a pollutant from industries such as electroplating. Water concentration of Cd >0.01 mg/L, like in network samples of Mit-Antar and Demera, has the potential to cause anemia, growth retardation and hypertension.[9] Webb reported that the geochemical effects of Cd on human health appear as bone and renal failure in populations drinking a contaminated water.[10]

Ni though an essential trace element is toxic in large amounts. Toxicity with Ni is

TAKE-HOME MESSAGE

- There are many health problems reported in association with aluminum in water.
- Cadmium is found in surface water as a pollutant from industries such as electroplating.
- Nickel though an essential trace element, is toxic in large amounts.
- Lead is a non-essential and highly toxic cumulative trace element in man.
- Continuous chemical analysis of surface drinking water is required to ensure that it is suitable for domestic purposes.
- Aluminum, cadmium, nickel and lead concentrations in surface drinking water samples of Dakahlia Governorate are higher than the permissible limits of EMH (2007) and WHO (2008).

enhanced in presence of Co, Cu, Fe, and Zn in drinking water. Kaaber, *et al.*, reported worsening of eczema for those exposed to high levels of Ni.[11,12]

Pb is a non-essential and highly toxic cumulative trace element in man. It is present in tap water to some extent as a result of its dissolution from natural sources; Pb is primarily from household plumbing systems containing lead in pipes, solder, fittings or the service connections to homes. Levels of Pb in drinking water sampled at the source are usually <5 µg/L. However, tap water taken from homes where lead is present in the plumbing can contain levels up to 100 µg/L.[13] The presence of lead in water usually indicates contamination from metallurgical wastes or from lead-containing industries. Lead concentrations in the network water samples of Shoha, Mit-Antar, Demera and Nabaru exceeded the permissible limits of EMH[5] and WHO[6]. Lead after absorption, enters the blood where it is rapidly taken-up by the erythrocytes. High concentration of lead in the body can cause death or permanent damage to the central nervous system, the brain and kidney.[14] The damage commonly results in behavior and learning problems. Lead crosses the placenta easily throughout gestation[15] and is usually associated with poor pregnancy and neonatal outcomes. Other heavy metals are within the permissible limits.

Considering the current situation, continuous chemical analysis of surface drinking water is required to ensure that it is suitable for domestic purposes. Since most of the measured heavy metals are most likely originate from steel, plastics and batteries industries working in the region, we believe that activities of these industries must be stopped or at least limited in urban zones. We should also emphasize on using appropriate materials and engineering practices to minimize plumbing solvency in water treatment and water distribution systems.

Conflicts of Interest: None declared.

References

1. Abd el Daiem AA, Ramsussen KR. A mathematical model for the north part of the Nile Delta Quaternary aquifer, Egypt. *Journal of Environ Sci* 1991;**3**:339-63.
2. Skeat WO. Manual of British Water Engineering Practice. vol. b *Water Quality and Treatment*. The Institution of Water Engineers, London, England, **1969**.
3. Groopman JD, Wolff T, Distlerath LM. Substrate Specificity of Human Liver Cytochrome P-450 Debrisoquine 4-Hydroxylase Probed using Immunochemical Inhibition and chemical Modeling. *Cancer-Res* 1985;**45**:2116-22.
4. American Public Health Association (APHA). *Stan-*

dard Health Methods for the examination of water and wastewater. 19th ed. New York, **1992.**

5. Egyptian Ministry of Health (EMH). Standards and specifications of water quality for drinking and domestic uses. Internal Report. **2007**:8.
6. WHO. Guideline for drinking water quality. 3rd ed, vol. 1, Recommendations. World Health Organization, Geneva, **2008**.
7. Witt VM. Developing and applying international water quality guidelines. *Journal of the American Water Works Association* 1982;**74**:178.
8. Jackson MH, Morris GP, Smith PG, Crawford Jf. Water resources, quality and pollution. *Environmental Health (Reference Book)*, London. Butter Worths, **1989**.
9. Green LW, Anderson GL. *Community health*. 5th ed Times Mirrer / Morsby College Publishing. **1986**.
10. Webb M. *The geochemistry, Biochemistry and Biology of Cadmium*. Elsevier / Noyth Holland Biomedical Press, Amsterdam, **1979**.
11. Kaaber K, Vein N, Tjell JC. Low nickel diet in the treatment of patients with chronic nickel dermatitis'. *Br J Derma.* 1978;**98**:197-201.
12. Kaaber K, Menene T, Tjell JC, Vein N. Ant abuse treatment of nickel dermatitis". *Contact Derm*. 1979;**5**:221-8.
13. Sherlock JC, Pick ford CJ, White GF. Lead in alcoholic beverages. *Food additives contamination* 1986;**3**:347-54.
14. Jenning GD, Sneed RE, St Clair MB. *Metals in drinking water.* North Carolina Cooperative Extension service. Publication no AG–473-1. Electronic ver 3, **1996**.
15. Goyer RA. Transplanted transport of lead. *Environ Health Prospect* 1990;**89**:101-5.