Assiut University Journal of Chemistry (AUJC) 50(2021) 1-12

Journal homepage: www.aujc.org

(ISSN 1678-4919) (Print) (ISSN 2357-0415) (Online)

Vol(50)	No(1)	2021

Full Paper

Temporal Variation of Lead and Cadmium in Nile Water, Assiut City, Egypt

Mahmoud A.Ghandour*, Azza M.M. Ali and Hoda A.Mohamed Atef

Department of Chemistry, Faculty of Science, Assuit University, Assuit, Egypt.
*Corresponding Author E- mail address: ghandour10@live.com.

Article history: Received: 23/2/2021; Revised: 7/3/2021; Accepted: 25/3/2021; Available Online: 1/6/2021;

Abstract

In aquatic habitats , metal concentration from natural and anthropogenic sources continues to pose aconcern for human and environmental health. Lead and cadmium, among other heavy metals, often seriously deteriorate water quality. Temporal fluctuations of the metal concentrations in samples from River Nile at Assiut City were collected daily and monitored on a weekly basis over a period of ten months, from October 2016 to July 2017. The samples were analysed by Inductively Coupled Plasma Optical Emission Spectrometry (ICPOES). It was found that the concentrations of elements differ from season to another as concentration in Autumn > Winter > Summer > Spring. Average concentration range of lead was 2.50 - 9.30 µg/L while that of cadmium was 0.02 - 0.72 µg/L. Lead and cadmium were found in lower concentrations than those recommended by World Health Organization (WHO), European Commission (EC) and U.S. Environmental Protection Agency (EPA) rules. The quality of Nile Water concerning the levels of lead and cadmium was compared with some international rivers indicating the superior quality of the Nile.

Key words: Nile River, Egypt, Assiut, Lead, Cadmium, ICPOES.

1. Introduction

The Nile is a major north flowing river in north eastern Africa. The Nile is the largest river in Africa and in the world. It is an international river as its basin cover 11 countries [1]. The main sources of the Nile are three Tributaries, the Blue Nile (68%), Atbara (22%) and the White Nile (10%) [2]. The most section of the river flows north , then ends in a large delta and flows into the Mediterranean sea. The River Nile is the main source (95%) of fresh water in Egypt. On the other hand, 94% of Egypt area is desert. Egypt will be suffering from water scarcity due to the rapid population growth [3]. Furthermore, the construction of the Grand Ethiopian Renaissance Dam (GERD) will reduce the Blue Nile share especially during the filling stages through period of drought and dry years. Therefore, an agreement is needed with downstream countries, Egypt and Sudan .The water quality is considered the main factor controlling the state of health and disease in both man and animal. Chemical pollution of aquatic system is due to the increasing use of the waste chemical industrial, agricultural and domestic drainage systems which lead to the pollution of the water with heavy metals.

The most heavy metals that bring about water pollution are iron, zinc, cadmium, copper, lead, chrome, nickel and mercury. However, some of these metals e.g. Cu, Cr, Fe and Zn are essential trace metals to living organisms. Others, such as Pb and Cd are toxic elements, even in trace amounts [4].Various environmental factors such as temperature, pH, water hardness, dissolved oxygen, light, salinity and organic matter can affect the toxicity of heavy metals probably contaminate the river water [5].

There are many reports describe the determination of lead and cadmium in Raw Nile Water covering the river trunk from lake Nasser to its estuary at the Rosetta and Damietta branches of Delta. Spatial and temporal fluctuation of the metal concentration in Nile Water have been noticed in the literature [6-9].

The sources of heavy metals mentioned above raise adverse effect since they have potential of bio-accumulation and bio-magnification [10]. Lead and cadmium enter the human body through water and food and may eventually accumulate to toxic levels. In case of Cadmium this lead to anemia, damage of proximal tubules, severe bone pain and mineral loss. Lead is harmful to the autoimmunity in which person's immune system attacks its own cells. This lead to kidney impair, nervous system and brain damage [11].

Degradation of Nile River water quality is a major issue in Egypt. This is due mainly to discharge agricultural and industrial effluents. The water quality released from Aswan High Dam (AHD) remains relatively clean from contamination. However, the industrial effluents start from Aswan through KIMA Company (production of ammonium nitrate fertilizer), in addition to some cane sugar plants discharge the industrial sewage into the river where the harvesting of the cane is in January to May each year. It is worthy to mention that submerged irrigation is applied to agricultural soils, therefore, agricultural drains add further contamination with heavy metals. However, some drains are in compliance with Egyptian standards that regulate the acceptable quality of the waste water discharged into the Nile [12].

The main objective of this study is to evaluate the presence of lead and cadmium in the Nile Water during the four seasons from October 2016 to July 2017 to investigate the influences of anthropogenic activities on the water quality. Assiut is a city located 375 kilometers (375km) south of Cairo.

2. Experimental

Geographical location

The area of the study is located upstream of Nile River after the new Barrage which located at the north of the old one (IBRAHEEMIA), Fig.1. Water samples were collected just under the surface from the midpoint of the river. The longitude and latitude of the site is 31°11′ 37″ E and 27°11′ 35.9″ N, respectively.

Water sampling

Water samples were collected daily and placed in clean polyethylene bottles prewashed three times with river water and immediately transported to the laboratory and kept below 4°C [13] in refrigerator .5mL from each sample were mixed together every week and this composite sample was filtrated twice through filter paper (2µm) followed by 0.45µm membrane filter [14].The pH was maintained constant at the in situ value for further investigation of the copper complexation capacity of the samples. The weekly samples were stored frozen until analysis [15].

Analysis methods

The water samples were examined for the presence of lead and cadmium using ICPOES (Inductive Coupled Plasma Optical Emission Spectrometry), model ICAP 6200 series, Thermo scientific company, England, located at the central laboratory; Faculty of Agriculture, Assiut University .The parameters of the instrument are shown in Table 1. The precision of water quality analysis was controlled using triplicate readings for each analysis with relative standard deviation less than 3%.

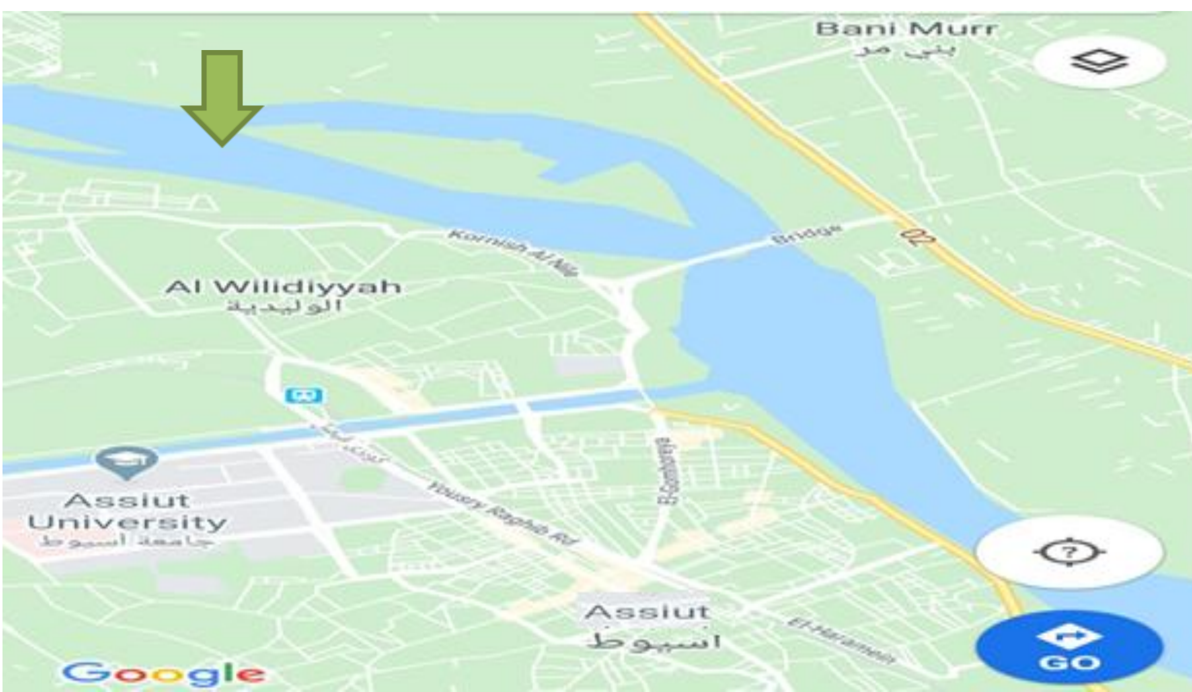

Fig.1. Map of sampling site.

Table 1. Parameters of the ICPOES.

RF Power (W)	**1150 W**
Gas flow rate (ml/min) :-	
Auxiliary gas	0.5 L/min
Coolant gas	12 L/min
Nebuliser Argon Flow	0.6 L/min
Center tube	1.5 mm
Torch	Axial
Elements monitored (wave length ,nm)	Cd (214.438) , Pb (220.353).

3. Results and Discussion

Weekly monitored lead and cadmium levels in Nile water at Assiut city are summarized in Table 2 and Fig. 2a – Fig. 2d.It can be seen that there is temporal fluctuation of the metals concentration. However, average results are lower than the maximum allowed values established by WHO (World Health Organization), EC (European Commission) and USEPA (United States Environmental Protection Agency) for drinking water [16] as shown in Table 3.

The levels of metals are in the order Autumn >Winter>Summer>Spring. The higher concentration of both metals in Autumn and Winter is due to the control of water volume body by the Aswan Reservoir and Aswan high Dam (AHD), whereas lower concentration is noticed in Summer and Spring where more water is released from AHD before and during flood season. However, most of results of cadmium were below the detection limit in Spring and Summer, i.e, cadmium was detected only in two weeks in June. The higher concentration in Summer than Spring is due to the increase of the evaporation rate of the water where the atmospheric temperature is~ 35-44°C in Upper Egypt. Furthermore, huge quantities of Nile water is consumed in domestic, industrial and agricultural needs. It is worthy to mention that agriculture in Egypt depends mainly on submerged irrigation. Therefore, bulk effluents loaded with contaminates enter Nile water body.

The number of samples collected from the same point at definite time may affect the net results. The dissolved concentration of heavy metals have been shown to vary considerably throughout the day due to anthropogenic and ecological factors. Therefore, it has been recommended to collect the samples three times within the day, morning, midday and, evening to observe diurnal (24h) concentration pattern of heavy metals [17].

Table 2: Average concentration of Cd and Pb.

Season	Duration	Cd µg/L	Pb µg/L
Autumn	24/10/2016 : 29/10/2016	0.4	9.2
	14/11/2016 : 17/11/2016	1.2	12.1
	19/11/2016 : 24/11/2016	0.6	9.1
	26/11/2016 : 01/12/2016	0.7	8.6
	03/12/2016 : 08/12/2016	0.7	7.1
Winter	28/1/2017 : 03/02/2017	0.3	7.7
	04/02/2017 : 10/02/2017	0.5	12.2
	11/02/2017 : 17/02/2017	0.6	12.2
	18/02/2017 : 24/02/2017	1.4	3.2
	25/02/2017 : 03/03/2017	0.2	8.2
	04/03/2017 : 10/03/2017	bdl	9.3
	11/03/2017 : 17/03/2017	0.2	8.2
Spring	18/03/2017 : 24/03/2017	bdl	3.5
	28/03/2017 : 03/04/2017	bdl	2.2
	04/04/2017 : 10/04/2017	bdl	2.3
	11/04/2017 : 17/04/2017	0.2	3.6
	18/04/2017 : 23/04/2017	bdl	2.9
	24/04/2017 : 30/04/2017	bdl	1.5
	01/05/2017 : 07/05/2017	bdl	2.6
	08/05/2017 : 14/05/2017	bdl	2.1
	16/05/2017 : 22/05/2017	bdl	0.6
	23/05/2017 : 29/05/2017	bdl	3.7
Summer	30/05/2017 : 05/06/2017	bdl	0.7
	06/06/2017 : 12/06/2017	0.5	6.5
	13/06/2017 : 19/06/2017	bdl	2.2
	20/06/2017 : 26/06/2017	bdl	1.1
	27/06/2017 : 03/07/2017	0.7	9.1
	04/07/2017 : 10/07/2017	bdl	0.4
	11/07/2017 : 17/07/2017	bdl	1.8
	18/07/2017 : 24/07/2017	bdl	bdl

bdl: below detection limit

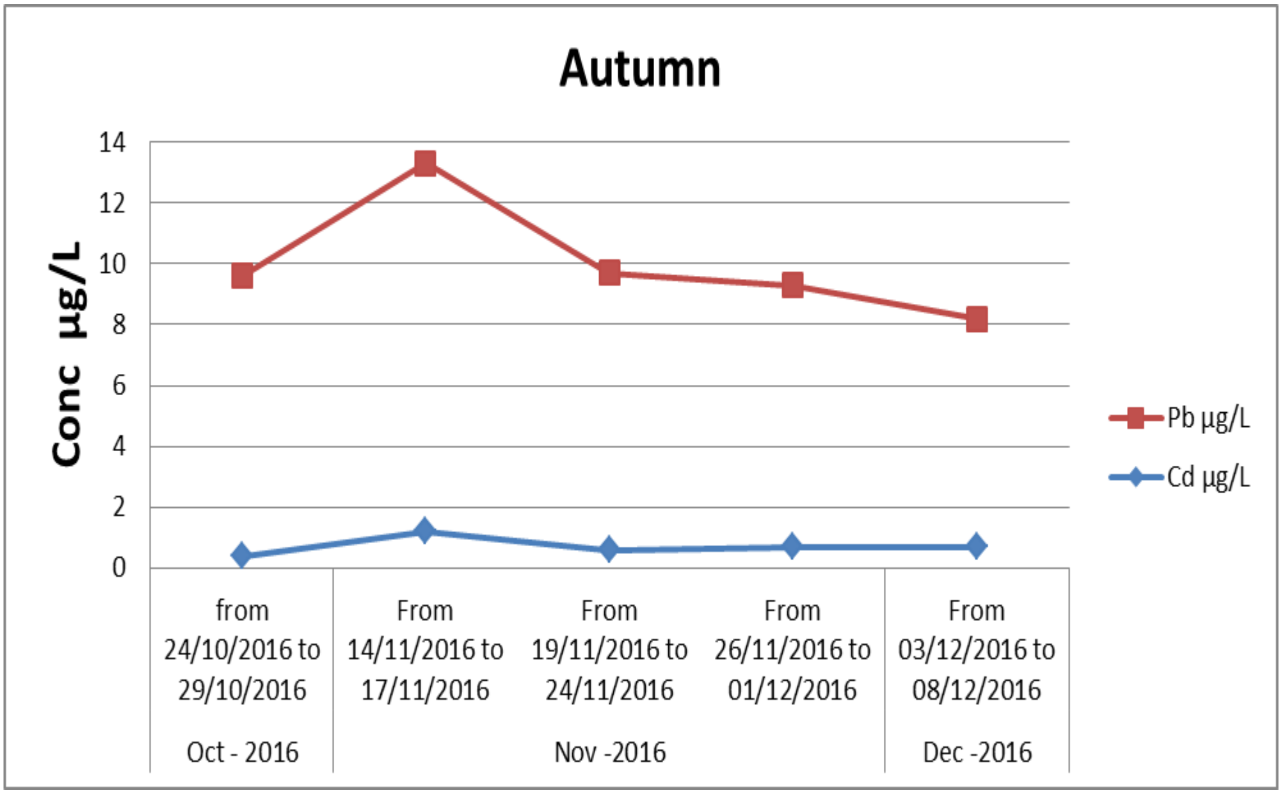

Fig. 2a. Concentration of Pb and Cd in Autumn.

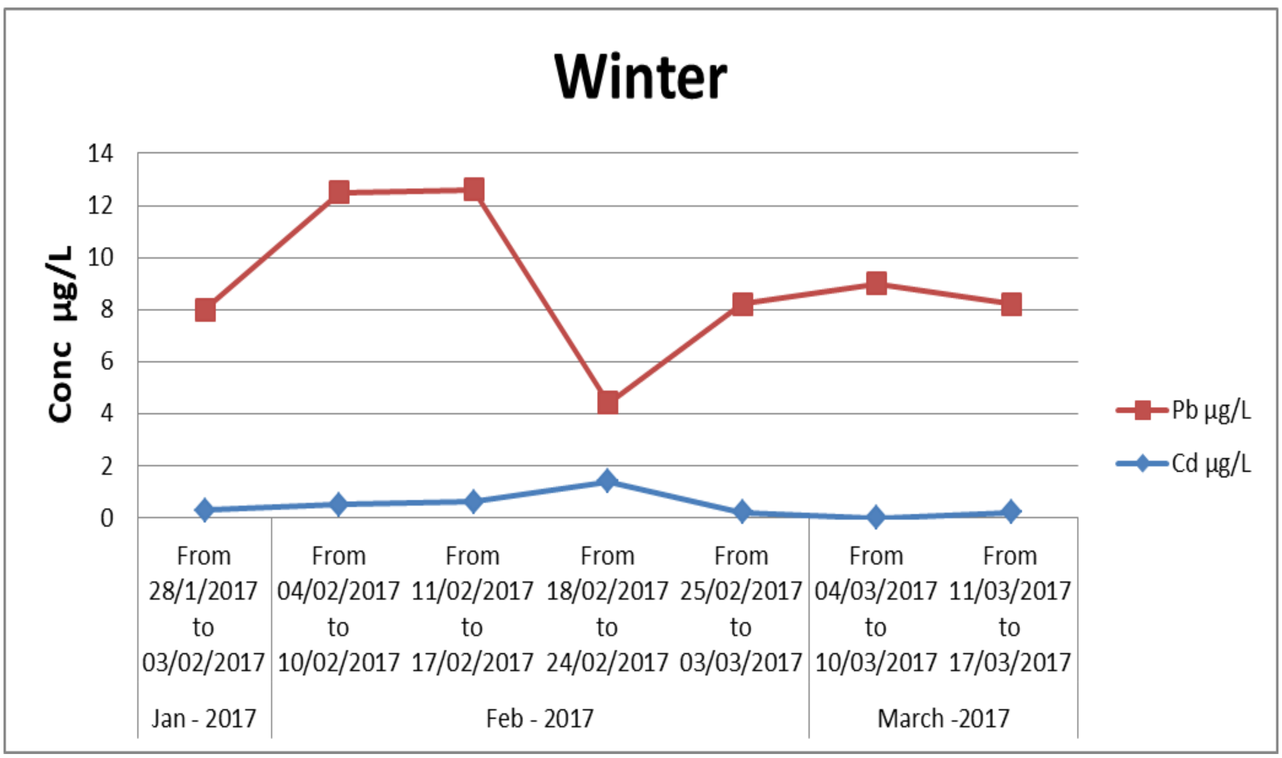

Fig. 2b. Concentration of Pb and Cd in Winter.

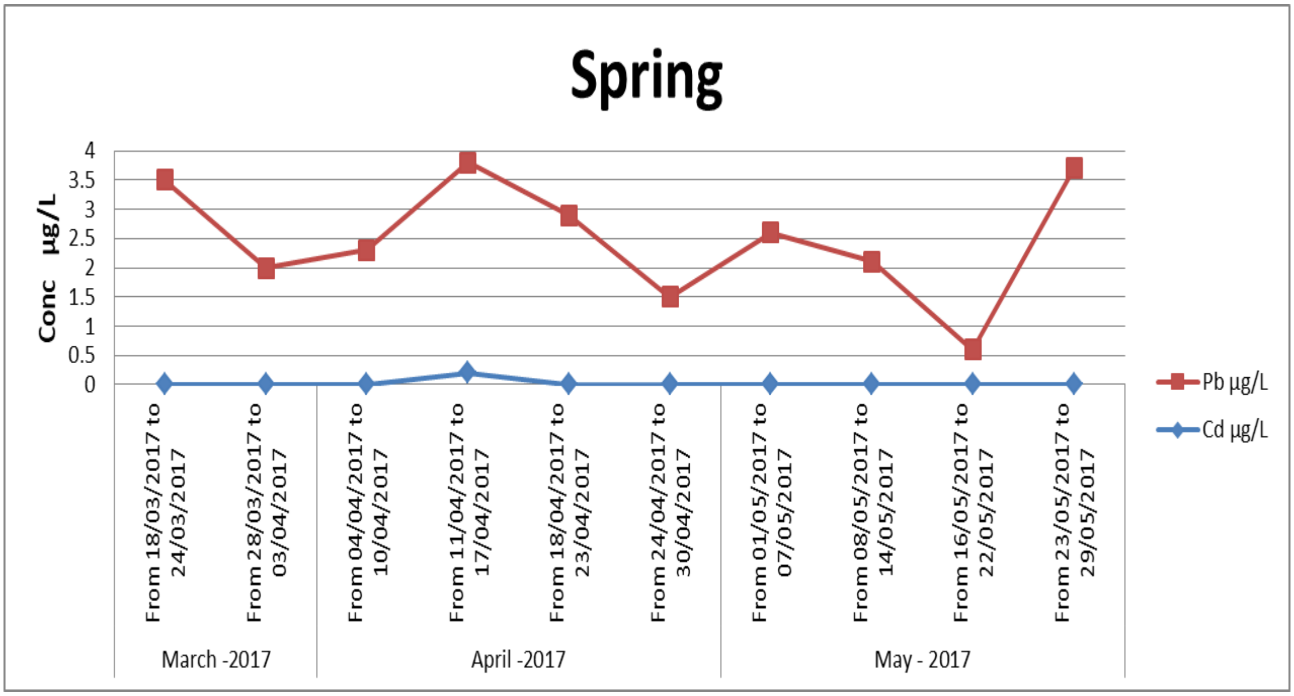

Fig. 2c. Concentration of Pb and Cd in Spring.

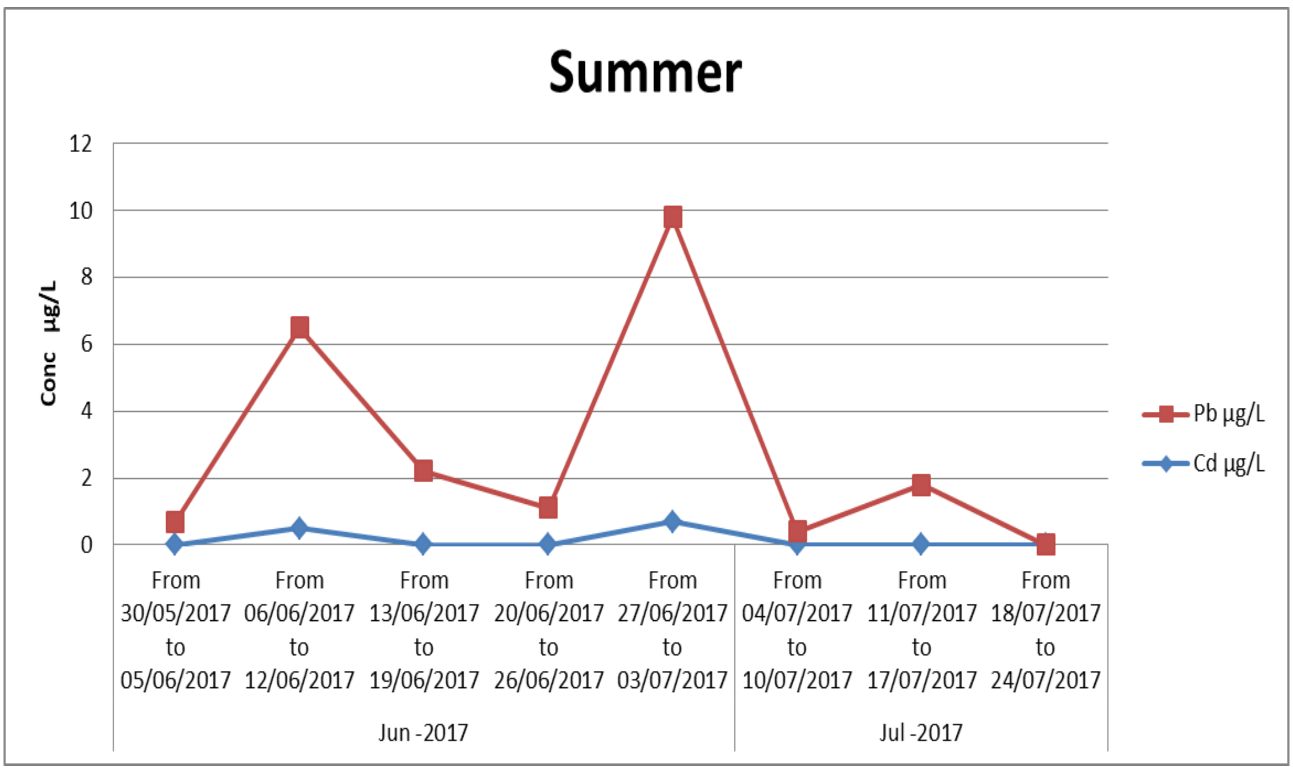

Fig. 2d. Concentration of Pb and Cd in Summer

Table 3. Comparison of the average concentration of Cd and Pb in each season and international regulation.

Season	Cd (µg/L)	Pb (µg/L)
Autumn	0.72	9.30
Winter	0.46	8.71
Spring	0.02	2.50
Summer	0.15	2.72
EC (1998)	5	10
WHO (2004)	3	10
USEPA (2009)	5	15

Table 4. Temporal analysis of Cd and Pb at Assiut city, µg/L.

Authors	Cd (µg/L)	Pb (µg/L)	Duration	Pre-treatment	Reference and Method
Alaa.G.M.Osman (from Aswan to Rosetta branch)	6±0.007	2.4±0.017	Bimonthly (from July 2009 to Jun 2010)	Acidified by HNO_3 and filtered.	Graphite Furnace AAS (GFAA) [7].
Amaal M. Abdel satar (Aswan to Cairo)	0.4 - 5.4	10.0 - 21.3	Only one sample from different 24 sites	Digestion by Conc. HNO_3.	AAS [8]
Amaal M. Abdel satar (Idfo to Cairo)	-----	7.99 - 61.11	Seasonally (2000 to 2001)	Filtration with glass micro fiber filter (GF/C)	AAS [9].
Ahmed Th . A. Ibrahim (Assiut Governorate)	10.0 - 41.0	9.0 - 50.0	Six sites from summer 2011 to autumn 2012 at quarterly intervals	Filtered and acidified by HNO_3.	ICP-MS [18].
Ghandour et. al. (Assiut)	0.02 – 0.72	2.50 – 9.30	Daily from October 2016 to July 2017	Filtration	ICPOES (Present work)

It has been noticed that there is a report in the literature indicates that the levels of Cd and Pb in Nile water at Assiut city were 0.4 - 5.4 µg/L and 10.0 - 21.3 µg/L respectively [8]. However in other report Pb values were characterized by remarkable seasonal variations and fluctuated between 7.99 to 61.11µg/L [9].These values may due to the analysis of the metal ions after water sample digestion or acidification by conc.HNO_3, where these trace elements could be leached from particulate matter. Another factor may be due to the anthropogenic activity during collection of the samples.

Differences in results even within the same locations, at different hydrogeological years, indicate possible point source contamination, seasonal variation and pretreatment steps of the samples before analysis [7, 8, 9, 18] as can be seen from Table 4.

Because of the excessive importance of studying the concentration of heavy metals in water, many countries have undertaken studies to evaluate their concentrations in order to manage the treatment from their increase in the permissible rates. They use different methods like mass spectroscopy, atomic absorption spectrophotometry and inductive couple plasma atomic emission spectroscopy [19-27]. Data in Table.5 were collected to compare the quality of their rivers and Nile River.

Table 5. Concentration of Lead and Cadmium in different rivers

Country	River	Cd µg/L	Pb µg/L	Reference and Method
Brazil	São Francisco River	6 - 23	3 - 23	IUPAC adapted method and processed in an atomic absorption spectrophotometer [19].
	Todos os Santos River	0.001 - 0.024	0.018 - 3.67	An inductively coupled plasma mass spectrometer (ICP-MS, ELAN DRC II, PerkinElmer) [20].
Bangladesh	Rivers in Dhaka city	Lowest concentration compare with other trace element.	2.9 - 8.1	Inductively coupled plasma mass spectrometer (ICP-MS, Agilent 7700 series ,USA) [21].
Kenya	River Kuywa in Bungoma County	(320±0.02-990±0.67)	(570±0.09 - 3360±1.15)	Flame atomic absorption spectroscopy [22].
Iran	Damavand River	(30±0.00) - (1030±0.5)	(90±0.00) - (800±3.13)	Atomic absorption spectrophotometer [23].
Nigeria	Ipo stream in Ikwerre District of rivers state	1.5	23.32	Atomic absorption spectrophotometry model 3700 [24].
	River Challawa	60 to 710	1100 to 9000	Atomic absorption spectrophotometer (AAS) [25].

Table5. ***Continued***

Country	River	Cd µg/L	Pb µg/L	Reference and Method
China	Taipu River	2	57	An inductively coupled plasma atomic emission spectroscopy [26].
	Wusong River	4	77	
Pakistan	Rawa Lake	6 - 25	162 - 223	
Ghana	Ghana Rivers	ND	0.85	
Nanjing	Yangtze River	5	55	
Italy	Lambro River	4.8	138.8	
Turkey	DilDeresi (stream)	7	80	
India	Hindon River	12	276	
Sudan	White Nile River	0.003	0.169 - 0.409	Atomic absorption spectroscopy [27].
Egypt	Nile River in Assiut city	0.02 – 0.72	2.50 – 9.30	Present work (ICPOES).

4. Conclusions

Though with discharge of some industrial and agricultural effluents in Nile , the large volume body of the river minimize the levels of the two heavy metals Cd and Pb during all seasons where their levels are below the guidelines of WHO (World Health Organization) , EC (European Commission) and USEPA (United States Environmental Protection Agency) for drinking water.

5. References

1. Wikipedia.org/wiki/Nile. Accessed on Feb.22.(2020)
2. E. Garzanti, S. Ando, M. Padoary, G. vezzoli and A. Elkammar , Quaternary Sci. Rev. 1309-56. (2015)
3. E.O. Lawson, Advances in Biological Research, 5 (1): 08-21. (2011)
4. I.M. Shoker, G.H. Rabie, A.A. Ismaiel and M.T. Mekawy, Middle East Journal of Applied Sciences, 5(3): 742-750. (2015)

5. G.W. Bryan, Proc. Roy. Sac. London B, 177: 389 – 410. (1971)
6. H. M. Bayomy and M. A. Rozan, J. Food and Dairy Sci., 6 (4): 253 – 262. (2015)
7. A.G.M. Osman and W. Kloas, Journal of Environmental Protection, 1:389-400. (2010)
8. A.M. Abdel-Satar, M.H. Ali and M.E. Goher, Egyptian Journal of Aquatic Research, 43:1-29. (2017)
9. A.M. Abdel-Satar, Egyption Journal of Aquatic Research , 31(2): 200-223. (2005)
10. P.W. Wasike, M.P. Nawiri and A.A. Wanyonyi, Environment and Ecology Research, 7(3):135-138. (2019)
11. A. Uzairu, O.J. Okunola, R.J. Wakawa and S.G. Adewusi , Journal of Applied Chemistry , Hindawi publishing corporation , 1-9. (2014)
12. Agriculture Policy Reform Program. Survey of Nile system pollution sources, Ministry of water resources and irrigation agriculture policy reform program. Water policy program, Report No.64.(2002)
13. S.S. Withanachchi, G. Ghambashidze, I. Kunchulia, T. Urushadze and A. Ploeger International Journal of Environmental Research and Public Heath,15:621.(2018)
14. M.A. Fawzy, N.E. Badr, A. El-Khatib and A. Abo-El-Kassem, Environ Monit Assess 184:1753 – 1771. (2012)
15. F. Delgadillo-Hinojosa, A. Zirino and C. Nasci, Marine Environmental Research, 66:404-411. (2008)
16. I. M. Adesiyan , M.B.Johnson , O. T.Aladesanmi , A.I. Okoh and A.O. Ogunfowokan , Journal of Health Pollut.8(19): 180907. (2018)
17. D. A. Nimick,Ch.H.Gammons,Th.E.Cleasby,J. P. Madison,D.Skaar,and Ch.M. Brick , Water Recourses Research,39(9):1247.(2003)
18. A.Th.A. Ibrahim ,H.M.Omar, Journal of Biology and Earth Sciences ,3(2):236 – 248.(2013)
19. A. M. Souzaa , A. M. Salvianob, J. F. B. Meloa ,W. P. Felixa,C. S. Beléma and P.N. Ramos, Braz.J. Biol., 76 (4):967-974. (2016)
20. C.A.F. Pereira and L.F.O. Maia, An Acad Bras Cienc 90(3) : 2701-2710. (2018)
21. M.S.Islam, S.HAN , M.K.Ahmed and S.Masunaga ,Journal of water and environment technology ,12(2):109-121. (2014)

22. P. W. Wasike., M. P. Nawiri and A. A. Wanyonyi , Environment and Ecology Research 7(3): 135-138. (2019)
23. ,S. Khoramnejadian and F. Fatemi , Applied Ecology and Environmental Research 15(1):439-444 . (2017)
24. K.Friday, O. Ekpete and I.Loveday,J.Appl.Sci. Environ. Manage. , 13(2) 63-67. (2009)
25. A. Uzairu,O. J. Okunola,R. J. Wakawa and S. G. Adewusi, Journal of Applied Chemistry , 9 pages. (2014)
26. H.X.Yao , Int.J.Environ.Res.Public Health ,11: 11860-11878. (2014)
27. A. S. Hamed and D. I. Alim ,International Journal of Advanced Research, 3(10) 1270-1275. (2015)