ISSN 2347-6893
Volume 10 Number2
Journal of Advances in Biology

The Impact of some Organic and Inorganic Pollutants on Fresh Water (Rashid branch, River Nile), Egypt

[1]Eman H. Radwan, [2]Gehan H. Fahmy, [3]Mennat Allah Kh. Saber and [4]Mohie ElDin Kh. Saber
[1]Damanhour University, Faculty of Science, Zoology Department, Egypt.
Dr_eman_hashem@yahoo.com, Eman.radwan@Sci.dmu.edu.eg
[2]Alexandria University, Faculty of Science, Zoology Department, Egypt.
gfahmy2014@yahoo.com
[3]Alexandria University, Faculty of agriculture, Dairy Department, Egypt.
MannatAlalh_kh@yahoo.com
[4]Alexandria University, Faculty of Science, Geology Department, Egypt.
Mohie_kh@yahoo.com

ABSTRACT

Pollution of fresh water with organic pollutants and heavy metals has an impact on the environment of the River Nile in Egypt. The environment has become increasingly contaminated by inorganic and organic pollutants which accumulate in the food chain and affect the human health. The pollution of the fresh water environment by heavy metals and organic pollutants is due to the increasing action of flowing out discharge from various industries.

Three heavy metals; Cu, Pb, and Zn and organic pollutants as DDT, chlordane, dieldrin and butylene were investigated in the present study in freshwater and sediment during the year (autumn 2016 – summer 2017). The investigated samples were collected from Rashid branch of the River Nile, Egypt. The present study reported that the mean concentration level of both heavy metals and organic pollutants were correlated in the sediment and in the fresh water of Rashid at $p< 0.001$.

Key words: Environment – pollution - organic pollutants - inorganic pollutants - fresh water.

INTRODUCTION

It was found that both inorganic and organic chemicals can stimulate free radicals production ([1,2]). Toxic metals such as copper and lead are released into environment from industrial and urban sources. Metal introduced into the marine environment tend to accumulate in the sediment ([3]). Metallic contaminants are present in urbanized estuaries through inputs from a variety of sources, including urban runoff, industrial effluents, boating activities and sewage treatment plant effluents, and may enter the aquatic environment via low dose continual influx spill events ([4]). Among the greatest of metallic input is lead, both by frequency of occurrence and concentrations in contaminated waterways often being elevated ([5], [6]). Lead is a non-essential metal, is accumulated rather than regulated by most aquatic taxa, and exerts toxic effects at lower concentrations than many other metallic contaminants ([7]).

A concern about persistent organic pollutants (POPs) has been proved to be substantiated. These substances are usually present in the sea at very low concentrations. Because of their persistence, they are accumulated in the tissues of the aquatic organisms at high concentrations. Genotoxic compounds such as POPs may cause mutagenesis to the aquatic organisms. Pesticides enter the waterways along with agricultural and urban waste. These toxic compounds are known to be hydrolyzed quite rapidly in the environment ([8]). Pollutants are currently dispersed within the environment ([9]). Pesticides are any substance or mixture of substances intended for preventing, destroying, including insecticides, herbicides, fungicides and various other substances used to control pests ([10]-[14]). The agricultural sector is the primary user of pesticides, consuming over four million tons of pesticides annually ([15], [16]).

Resistance may be defined as a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species ([17]). Important crop pests, common urban pests and disease vectors, some cases have developed resistance to such an extent that their control has become exceedingly challenging ([18]- [20]).

MATERIAL AND METHODS

The Sampling Locatin:

The River Nile, Rashid, Egypt during the four seasons of the year. Investigations started in autumn season 2016 (September, October and November) followed by winter season (December, January and February), then spring season (March, April and May) ending with Summer season (June, July and August 2017).

Statistical Analysis of the Data: Statistical analysis to study the difference between concentrations in the year 2016-2017, samples of water and sediment from water of Rashid were studied. Data of freshwater were fed to the computer and analyzed using IBM SPSS software package version 20.0. Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp). The Kolmogorov-Smirnov, Shapiro and D'agstino tests were used to verify the normality of distribution of variables, ANOVA was used for compare two groups for normally distributed quantitative variables for comparing the four studied groups and followed by Post Hoc test (Tukey) for pairwise comparison. Pearson coefficient was used to correlate between quantitative variables. Significance of the obtained results was judged at the 5% level.

Specimen were cleared and frozen at -20^{o}C until analysis. This study determined the levels of Cu, Zn, Pb in fresh water collected from rashid location, nile river. For fresh water sample analysis; samples were filtered through 0.45 µm Millipore filters to remove any debris particles. Metal extraction was carried out coulorimetric method for elemental determinations in samples of water. All values are reported as µg/L for fresh water. Compsite sediment samples (30 gm) each made seven times replicates for elemental and organic analysis.

Methods of Analytical Techniques: Sampling was carried out seven times (replicants)/season from fresh water of rashid at the selected location during the period from 2016 to 2017. Sediments were digested at 120 C for 3 hrs., in the nitric perchloric acids mixture. Cu, Zn, Pb (µg/L wet weight) were determined in the acid digests. Fresh water samples were collected during sediment sampling. To avoid contamination, all the glassware was washed with double distilled water and soaked over night in 20% nitric acid. The analytical grade HNO_3 was double distilled in glass. All other chemicals were of highest purity. Sample preparation was undertaken in hoods to avoid any extraneous contamination.

Analysis of Heavy Metal

Trace metal Pb, Zn and Cu were determined using Graphite Furnace Atomic Absorption Spectroscopy (Perkin-Elmer model 2380) under the recommended conditions the detection limits (DL) in the manual for each metal ([21]). The preparation of sediment samples to determine concentration of heavy metals was carried out, wet diagested samples were diluted with deionized distilled water and analyzed by Ion-selective electrod AVL. The obtained data were expressed as µg/g wet weight ([22]). The analytical method was checked by (7 replicate) measurements for the studied metals in a sample of marine.

Sampling Bottom sediment samples were collected using a stainless steel grab sampler from the stations. Sampling was carried out using Salsabeel Research Vessel. Samples were stored in pre-cleaned aluminum containers and frozen in a deep freezer at -20C until analysis. Procedures water content were examined according to Strickland and Parsons. The samples were analyzed following the well-established techniques UNEP/IOC/IAEA . Sediments were freeze-dried, and their dry/wet ratios were determined. Sediments were then sieved through a stainless steel mesh (250µm). Each sediment sample (30g) was extracted with 250ml of n-hexane for 8 h using a soxhlet, and then re-extracted for 8h into 250 ml of methylene chloride. Then these extracts were combined and concentrated down to ~ 5ml using rotary evaporation at 35ºC followed by concentration with pure N2 gas stream down to a volume of ~ 1ml. Sulphur was removed by shaking the extracts with mercury. The final extracted volume (1ml) for each sediment sample was transferred to the top of a column chromatography. This column was prepared by a slurry packing10g of florisil, followed by 10g of alumina and finally 1g of anhydrous sodium sulfate. Elution was performed using 70ml of n-hexane for PCBs fractions, then a 50ml mixture (70% n-hexane and 30% methylene chloride) for Pesticides (DDT) fractions. Finally, eluted samples were concentrated under a gentle stream of purified nitrogen to about 0.3ml, prior to being injected into the GC/ECD (Thermo Scientific Company) equipped with 63 Ni-electron capture detector (ECD). The instrument was operated in split less mode (3µL split less injection) with the injection port maintained at 290ºC and the detector maintained at 300ºC. A fused- silica capillary column; Thermo TR-35 MS (30 m length, 0.25 mm i.d., 0.25 µm thickness) with 35% phenyl polysilphenylenesiloxane was used for the quantification. The temperature was programmed from 90˚C - 140˚C with rate of 5 ˚C min−1, then held at 140˚C for 1min, and from 140- 250˚C with rate of 3˚C min−1 and was held at 250˚C for 1min, and from 250- 300˚C with rate of 20˚C•min−1 and was held at 300˚C for 1min. The injector and detector temperatures were set at 280˚C and 310˚C, respectively.

RESULTS

The mean metal concentrations in fresh water and sediment in Rashid were collected seasonally during the year 2016-2017, are represented in table 1-10. The pattern of metal occurrence, in order of decreasing concentrations, were Zn>Pb>Cu in water and sediment.

Table 1 is showing that the mean concentration levels of Cu was reported with the average of 1.5 in the freshwater collected from Rashid, River Nile in autumn 2016 and winter 2017, and 1.6 in spring 2017 and summer 2017, it did not show a significant difference during the time of the study. Whereas, the mean concentration level of Pb was reported as 1.8 in autumn, winter and summer but it was 1.4± 0.5 in spring. The mean level of Zn concentration showed the average of 2.5 ± 1, 2.4 ± 0.9, 4.1 ± 0.7 and 2.3 ± 0.9 in autumn, winter, spring and summer; respectively.

For the organic pollutants, DDT was reported as 5.6 ± 2, 12.7 ± 16.1, 5.3 ± 2.6, 7.7 ± 4.1 in autumn, winter, spring and summer; respectively. The high level of DDT was found to be reported in winter followed by summer then comes autumn and spring. The high concentration level of chlordane was reported to be found in winter followed by summer then comes autumn and spring. The mean average level of chlordane was reported as, 2.4 ± 2.9, 8.2 ± 8.1, 2.9 ± 4.4 and 6.9 ± 9 in autumn, winter, spring and summer; respectively. Dieldrin showed a high concentration level in winter as 3.8 ± 2.8 in winter followed by 2 ± 1.8 in summer then comes autumn and spring. The butylene high average level was reported in winter followed by autumn as 1.4 ± 1.3, 1.1 ± 1 then followed by spring and summer.

Table 2 represents the correlation between different parameters in water collected in spring 2017 from Rashid station. Table 2 shows that Cu is highly positively correlated with Pb, DDT, chlordane, dieldrin and butylene as r= 0.734, 0.761, 0.656, 0.707 and 0.724; respectively. Whereas Pb showed a positive correlation with DDT, chlordane, dieldrin and butylene as; 0.595, 0.578, 0.627 and 0.607; respectively. DDT which is represented in table 2 is highly positively correlated with chlordane, dieldrin and butylene as r=0.964, 0.976 and 0.964; respectively. Whereas chlordane showed a high positive correlation with both dieldrin and butylene as, r=0.991 and 0.948. dieldrin was only positive significant with butylene as r=0.949, at $p<0.05$.

In Autumn 2016 Cu was positively correlated to Pb, DDT, chlordane, dieldrin and butylene as r=0.512, 0.586, 0.578, 0.628 and 0.654; respectively. The DDT showed high positive correlation to the chlordane, dieldrin and to butylene as well as r=0.834, 0.823 and 0.521; respectively. Whereas, the chlordane showed a high positive correlation to both dieldrin and butylene as r=0.991 and 0.798. The dieldrin showed only a high positive correlation to the butylene as r=0.860.

Table 4 showed the high positive correlation between Cu and Pb, Zn, DDT, chlordane and butylin as r=0.761, 0.684, 0.734, 0.673 and 0.722 respectively. The lead showed high positive correlation with Zn, chlordane, and butylene as r=0.613, 0.558, 0.505; respectively. Zn was positively correlated to DDT, chlordane, dieldrin and butylene as r= 0.845, 0.716, 0.574 and 0.862; respectively. The DDT showed positive correlation with chlordane, dieldrin, and butylene as r= 0.783, 0.527 and 0.968; respectively. Whereas, the chlordane showed a positive correlation with both dieldrin and butylene as r=0.774 and 0.871. The dieldrin was only correlated positively with the butylin as r=0.691.

Table 5 shows the correlation between the selected heavy metals and some organic pollutants in the freshwater of Rashid, Nile river in the period of june, july and august 2017. Table 5 shows a significant difference between Cu and Pb, dieldrin as r=0.778, 0.504; respectively. Pb showed a significant positive correlation with Zn, DDT, chlordane and dieldrin as r= 0.520, 0.873, 0.670, 0.890; respectively. Zn was positive correlated to DDT, dieldrin as r=0.766, 0.707, whereas it was negative correlated to the butylin as r=-0.521. The DDT was positive correlated only to both chlordane and dieldrin as r=0.649 and 0.985; respectively. Whereas the chlordane showed only a positive correlation with dieldrin as r=0.752 at $p<0.05$.

Table 6 shows that the mean concentration level of Zn in sediment in summer differ significantly from autumn,winter and spring, it is reported as; 9.1abc ± 0.6, 4.8a ± 0.5, 5.4 ± 0.5, 6.1 ± 0.4; respectively. Whereas, the higher level is reported in summer followed by spring, winter and autumn. The mean concentration level of Pb in sediment in summer was reported to be differed significantly from that of autumn as 2.8b ± 0.1, 1.9 ± 0.4; respectively. The highest mean concentration level of Cu was reported to be in winter as 3.8b±1 followed by summer, spring, then autumn as 3.7b ± 0.4, 3.3 ± 1 and 2.6 ± 0.4; respectively. DDT mean concentration level was reported as; 51a ± 3.7, 39.7ab±1.1, 29.7 ± 0.9 and 26.1abc±0.8; respectively in autumn, winter, spring and summer; respectively. The mean concentration level of chlordane in sediment followed the following arrangement; summer, spring, winter and then autumn; respectively as; 26.2bc ± 1.6, 26.2 ± 1, 22.9ab ± 0.8, and 20.6a ± 0.7; respectively. The mean concentration level of deildrin differed significantly as following; autumn differes from spring . The highest concentration level of deildrin was reported in autumn followed by winter, summer then spring as; 9.4a ± 0.7, 8ab ± 0.5, 5.8bc ± 0.3 then 5.1 ± 0.9 respectively. The highest mean concentration level of butylene was reported in autumn followed by summer, winter then spring as; 5.1a ± 0.7, 4.1ab ± 0.6, 3.9ab ± 0.1 then 2.4 ± 0.3; respectively.

Table 7 shows that, Zn is highly possitively correlated with chlordane as r= 0.834 and Pb is positively correlated with DDT as r= 0.514. Cu showed a negative correlation with DDT as r= - 0.732 and positively correlated with chlordane as r= 0.897.

Table 9 showed that Zn in winter was positively correlated to diedrin as r =0.579 whereas, Pb showed only negative correlation with DDT and chlordane as r=-0.804* and -0.877*; respectively. DDT in sediment in winter, showed only positive correlation to chlordane as r =0.587. The chlordane showed also a positive correlation to the butylene as r=0.553. In sediment the dieldrin showed a negative correlation with the butylene as r =-0.642.

Table 10 showed that Zn has a negative correlation with Pb in sediment as r =-0.711 whereas Cu showed a positive correlation with DDT, chlodrdne, and butylene as r =0.524, 0.560, and 0.552; respectively. The DDT showed a positive correlation with the chlordane as r = 0.780*.

DISCUSSION

Inorganic Pollutants in Water (Zn, Pb, Cu):

Industrial and fertilizers may be present in the freshwater. Most of heavy metals find a chance to be in variance concentrations ([23]). Around the world the freshwater zones are subjected to the direct release of urban and industrial discharges, such inputs are known to contain heavy metals which may increase trace metal concentrations in the coastal zone, some of which are toxic and can endanger human health ([24]). Heavy metal values in water fluctuated within site; copper concentration showed a high value due to the effect of wastewater drainage ([25]). Regarding heavy metals various processes influenced by anthropogenic activities may be contributed to increase concentrations in natural waters, such as run-off from agricultural and urban areas, discharges from factories and leaching from industrial sites ([26] and [27]). El-Mex receives different types and amounts of effluents; agricultural, domestic and industrial effluents ([28]). [29]El-Rayis and Abd-Allah reported that Omoum Drain in Egypt after the construction of the Aswan High Dam and controlling of Nile River water flow becomes one of the main land based sources regularly discharging its water directly to the Mediterranean sea at El-Mex Bay west of Alexandria.

[30]Abou-Taleb *et al.* reported the relative high value of dissolved copper in Alexandria at Abu-Quir beach water (5.42 µg/L) is probably due to the local anthropogenic input of industrial wastes, leaching of copper from ships antifouling paints could be a possible source for copper in this area. In the present study, the high Cu level was might be due to leaching of copper from ships antifouling paints that could be a possible source for copper in Rashid. [31]Attia *et al.* reported high values of heavy metals Cu, 43µg/g in water samples taken from El-Temsah shipping company – such area was reported with a variety of industrial activity and receives industrial effluents – and Cu, 20 µg/g in water samples taken from Abu Quir beach. Abu Quir Harbour is a military harbor situated nearly between the dead and the open seas. It is affected by three continental discharges. There are the boughaz El-Maadia opening, the tapia pumping station and the opening of Rashid Nile branch ([32]). In the present study Cu level in freshwater is ranged between 1.5-1.6 µg/L for freshwater inRashid,Nile

river which is lower than the Critirion Maximum Concentration (CMC) level for copper which is 4.8 µg/L and the Critirion Continous Concentration (CCC) level which is 3.1 µg/L stated by United State Enviromental Protection Agency (USEPA, 2005). [33]Aboul-Dahab reported the concentration of dissolved Cu was 3.8 µg/L at El-Max Bay. [31]Attia *et al.* reported high values of heavy metals, Cu was 25 µg/g in water samples taken from El-Mex bay. [34]Shriadah and Emara reported a high level of Cu concentration of El-Mex (5.38µg/L). Inputs of trace metals in marine environment can be included as follows: pigments and paints, biocides, fuel: Cu. In 1993, Alexandrial General Organization for Sanitary Drainge (AGOSD) started to treat the Alexandria waste water drainage before discharging to Lake Maryut ([35]).

In the present study, Zn was found in freshwater of Rashid ranged between 2.3-4 µg/L. Abu-Quir station is at the eastern part of Alexandria coastline which receives a number of domestic waste water effluents ([36]Mahmoud et al.,1999). Anthropogenic sources, which contribute 96% of zinc discharged into the environment, include domestic sewage effluents ([37]). Trace elements enter the freshwater environment from both natural and anthropogenic sources. Entry may be as a result of direct discharges into ecosystems.The anthropogenic sources include domestic effluents. The high concentrations of Zn were recorded where drainage water are mixed with agricultural drainage that may lead to the increase of Zn concentration ([25], [38]). To protect aquatic environments the average concentration of total Zn should not exceed the CMC value (90 µg/L) and the CCC value 81 µg/L as stated by (USEPA, 2005). In the present study Zn concentration ranged between 2.3-4 µg/L, this is considered below that of USEPA (2005). [30]Abou-Taleb *et al.* reported that the highest value of Zn was found at El-Anfoshi as 7.01µg/L. In the present study the high concentrations of Zn were recorded in seawater were recorded as 3.26 µg/L for El-Anfoshi. [34]Shriadah and Emara reported Zn level at El-Mex coastal water as 22 µg/L and 55.47 µg/L; respectively. [39]Khaled recorded differences in Zn concentration in Abu-Quir and El-Mex respectively. She gave an average range between 53.55 and 28.20 µg/L, for Zn at Abu-Quir and El-Mex, respectively. [40]Prokop *et al.* and [41]Al-Turki and Helal reported that the mobility and leaching of zinc increases with the decreasing of pH content of the medium.

The metal which is of great concern in fresh and brachish waters is Pb ([42]). Aquatic water can receive significant inputs of lead from industry and sewage of the water sheds and lead concentrations in them can reflect these inputs ([38]). In the present study, the concentration of dissolved lead fluctuated between 1.4-1.8 µg/L. In the present study the Pb average concentrations in all seasons doesnot exceed the CCC 8.1 µg/L. limit that detected by USEPA (2005) calculated the CMC for Pb (210 µg/L) and the CCC 8.1 µg/L. [31]Attia *et al.* reported high value of Pb as 45µg/l in water samples taken from El-Temsah shipping company–such area is with a variety of industrial activity and receives industrial effluents – and (Pb, 30µg/Ll) in water samples taken from Abu Quir beach. The northwest winds generally cause the formation of shallow currents inducing transportation of coastal sediments to the east ([43], [44]). [34]Shriadah and Emara reported that the concentration of dissolved Pb at El-Mex as 0.4 µg/L. [45]Pangos *et al.* reported lead in Greece coastal water as (18-910 µg/L). The lead concentration in the eastern region of Mediterreanan sea showed the highest value 80 µg/L ([25]). [30]Abou-Taleb *et al.* found that Pb concentration in Abu-Quir beach was 4.6 µg/L.

[46]Tomazelli *et al.* observed large concentration of Pb in less impacted areas of Piraciaba and Mogi Guacu basins. This fact suggested that it was not possible to infer about concentrations of these heavy metals based only in a broad evaluation of human impacts. The transport of lead to the surface waters of the inshore zone is probably through aerosol fall-out especially in highly industrialized area.The aquatic environment trransport activity by a large number of medium and gaint vessels can be a source of lead to the Egyptian sea water ([38]). The unregulated and indiscriminate application of pesticides can cause adverse effects to human health. The extent of these effects depends on the degree of sensitivity of the organisms and the toxicity of the pesticides. Pesticides cause serious health hazards to living systems because of their bioaccumulation in non-target organisms ([11]).

Pesticides must be eliminated ([47]- [51]). Obsolete pesticides have accumulated in almost every developing country or economy in transition over the past several decades ([50]). It is difficult to estimate the exact quantities of obsolete pesticides because many of the products are very old and documentation is often lacking ([52], [53], [48]). Organochlorine insecticides were first used for pest management ([54]). Manufacturers and researchers are designing new formulations of pesticides to meet the global demand. The applied pesticides should only be toxic to the target organisms, should be biodegradable and eco-friendly to some extent ([55], [56]). The repeated use of persistent and non-biodegradable pesticides has polluted various components of water, air and soil ecosystem. The adaptation of the pest to the new environment could be attributed to the several mechanisms such as gene mutation, change in population growth rates, and increase in number of generations.

Pesticides being cheap, easy and effective means of managing pests, diseases and weeds are used extensively. The extensive, indiscriminate, excessive and wrong use of pesticides caused heavy damage to ecosystem leading to toxicity and pollution. Indiscriminate use of insecticides leads to resistance and resurgence of insect pests besides leaving residues causing environmental pollution ([57]- [61]). Many pesticides starting from DDT are withdrawn because of their non-target toxicity. Stringent measures are made to test non-target toxicity before registration of a new pesticide molecule. The effect of toxicity is misunderstood. Toxic effects of pesticides are very clear. Lethal effects are used to interpret pesticide toxicity ignoring the sublethal effects even by researches and regulative authorities. Agro-ecosystem comprises of plants, soil and water as its major component. The dynamic interaction between these components makes the ecosystem sustainable ([62- 68]).

Chlorpyrifos has short persistence in the environment as of several dissipation pathways that may proceed concurrently. In soil, dissipation of CPY is often biphasic with an initial rapid dissipation followed by slower breakdown. There is no predominant seasonal use of CPY, although there is to somewhat greater usage in the winter for tree crops in California and greater use in summer for certain field crops. The properties of CPY were assessed against criteria for classification as a persistent organic pollutant (POP) under the Stockholm convention ([68]). A review of the data on half-lives of CPY in soils and has shown the high variability attributed to soil organic carbon content, moisture, application rate and microbial activity. Fewer data are available for water and sediments ([69], [70]).

Figure 1: Map of Egypt showing the location Rashid city

Table 1. Comparison between the four studied groups (different seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution; (Cu, Pb, Zn) in fresh water, Rashid (Egypt)

Inorganic and organic pollutants	Autumn 2016 (n = 7)	Winter 2017 (n = 7)	Spring 2017 (n = 7)	Summer 2017 n = 7	F	P
Cu (Mean ± S.D.)	1.5 ± 0.5	1.5 ± 0.4	1.6 ± 0.5	1.6 ± 0.3	0.139	0.936
Pb (Mean ± S.D.)	1.8 ± 0.4	1.8 ± 0.5	1.4 ± 0.5	1.8 ± 0.7	1.052*	0.388
Zn (Mean ± S.D.)	2.5a ± 1	2.4a ± 0.9	4.1 ± 0.7	2.3a ± 0.9	6.804*	0.002*
DDT (Mean ± S.D.)	5.6 ± 2	12.7 ± 16.1	5.3 ± 2.6	7.7 ± 4.1	1.144*	0.351
Chlordane (Mean ± S.D.)	2.4 ± 2.9	8.2 ± 8.1	2.9 ± 4.4	6.9 ± 9	1.324*	0.290
Dieldrin (Mean ± S.D.)	1.4 ± 1.4	3.8 ± 2.8	1.3 ± 1.3	2 ± 1.8	2.258*	0.107
Butylene (Mean ± S.D.)	1.1 ± 1	1.4 ± 1.3	0.7 ± 0.5	0.8 ± 0.2	1.012*	0.405

F and P values for ANOVA test, significance between groups was done using Post Hoc Test (Tukey)

a: statistically significant with spring, b: statistically significant with autumn,

c: statistically significant with winter, *: statistically significant at $p \leq 0.05$

Table 2. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in fresh water, Rashid (Egypt). Correlation between the different parameters in Spring

		Pb	Zn	DDT	Chlordane	Dieldrin	Butylene
Cu	r	0.734	-0.072	0.761*	0.656	0.707	0.724
	p	0.060	0.878	0.047*	0.109	0.075	0.066
Pb	r		0.262	0.595	0.578	0.627	0.607
	p		0.570	0.159	0.174	0.132	0.148
Zn	r			0.321	0.479	0.440	0.503
	p			0.483	0.277	0.323	0.250
DDT	r				0.964*	0.976*	0.964*
	p				<0.001*	<0.001*	<0.001*
Chlordane	r					0.991*	0.948*
	p					<0.001*	0.001*
Dieldrin	r						0.949*
	p						0.001*

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

Table 3. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in fresh water, Rashid (Egypt). Correlation between the different parameters in autumn 2016

		Pb	Zn	DDT	Chlordane	Dieldrin	Butylene
Cu	R	0.512	0.006	0.586	0.578	0.628	0.654
	P	0.240	0.990	0.167	0.174	0.131	0.111
Pb	R		0.165	0.275	0.256	0.333	0.367
	P		0.723	0.550	0.580	0.465	0.418
Zn	R			-0.339	-0.249	-0.133	0.344
	P			0.457	0.591	0.776	0.450
DDT	R				0.834*	0.823*	0.521
	P				0.020*	0.023*	0.231
Chlordane	R					0.991*	0.798*
	P					<0.001*	0.032*
Dieldrin	R						0.860*
	P						0.013*

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

Table 4. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution; (Cu, Pb , Zn) in fresh water, Rashid (Egypt). Correlation between the different parameters collected from Rashid, Nile river, Egypt in Winter 2017

		Pb	Zn	DDT	Chlordane	Dieldrin	Butylene
Cu	R	0.761*	0.684*	0.734*	0.673*	0.475	0.722*
	P	0.047*	0.090	0.060	0.098	0.281	0.067
Pb	R		0.613*	0.404	0.558*	0.425	0.505*
	P		0.143	0.369	0.193	0.342	0.248
Zn	R			0.845*	0.716*	0.574*	0.862*
	P			0.017*	0.070	0.178	0.013*
DDT	R				0.783*	0.527*	0.968*
	P				0.037*	0.224	<0.001*
Chlordane	R					0.774*	0.871*
	P					0.041*	0.011*
Dieldrin	R						0.691*
	P						0.085

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$.

Table 5. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in fresh water, Rashid (Egypt). Correlation between the different parameters in freshwater collected from Rashid, Nile river, Egypt in Summer

		Pb	Zn	DDT	Chlordane	Dieldrin	Butylene
Cu	r	0.778*	0.131	0.465	0.351	0.504	-0.062
	p	0.040*	0.779	0.293	0.440	0.249	0.895
Pb	r		0.520	0.873*	0.670	0.890*	0.041
	p		0.232	0.010*	0.100	0.007*	0.931
Zn	r			0.766*	0.244	0.707	-0.521
	p			0.044*	0.597	0.076	0.231
DDT	r				0.649	0.985*	-0.095
	p				0.114	<0.001*	0.840
Chlordane	r					0.752	0.288
	p					0.051	0.531
Dieldrin	r						-0.009
	p						0.985

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

Table 6. Comparison between the different seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in sediment, Rashid, Nile river (Egypt)

	Autumn 2016 (n = 7)	Winter 2017 (n = 7)	Spring 2017 (n = 7)	Summer 2017 (n = 7)	F	P
Zn,Mean±S.D.	4.8^{a}±0.5	5.4±0.5	6.1±0.4	9.1^{abc}±0.6	98.015*	<0.001*
Pb,Mean±S.D.	1.9 ± 0.4	2.4 ± 0.5	2.5 ± 0.4	2.8^{b} ± 0.1	5.993*	0.003*
Cu, Mean±S.D.	2.6 ± 0.4	3.8^{b}±1	3.3 ± 1	3.7^{b}±0.4	3.847*	0.022*
DDT, Mean±S.D.	51^{a} ± 3.7	39.7^{ab}±1.1	29.7 ± 0.9	26.1^{abc}±0.8	213.719*	<0.001*
Chlordane,Mean±S.D.	20.6^{a} ± 0.7	22.9^{ab} ± 0.8	26.2 ± 1	26.2^{bc} ± 1.6	46.128*	<0.001*
Dieldrin, Mean±S.D.	9.4^{a} ± 0.7	8^{ab} ± 0.5	5.1 ± 0.9	5.8^{bc} ± 0.3	65.015*	<0.001*
Butylene, Mean±S.D.	5.1^{a} ± 0.7	3.9^{ab} ± 0.1	2.4 ± 0.3	4.1^{ab} ± 0.6	40.393*	<0.001*

F and P values for ANOVA test, Significance between groups was done using Post Hoc Test (Tukey)

a: Statistically significant with spring, b: statistically significant with Autumn

c: Statistically significant with winter, *: statistically significant at $p \le 0.05$.

Table 7. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in sediment, Rashid, Egypt in Spring

		Pb	Cu	DDT	Chlordane	Dieldrin	Butylene
Zn	r	0.153	0.765^{*}	-0.392	0.834^{*}	-0.097	0.070
	p	0.744	0.045^{*}	0.385	0.020^{*}	0.836	0.882
Pb	r		-0.264	0.514	0.014	-0.463	-0.179
	p		0.568	0.238	0.976	0.295	0.700
Cu	r			-0.732	0.897^{*}	0.141	-0.142
	p			0.062	0.006^{*}	0.763	0.762
DDT	r				-0.486	-0.186	0.099
	p				0.268	0.690	0.833
Chlordane	r					0.224	-0.186
	p					0.629	0.690
Dieldrin	r						0.415
	p						0.355

r: Pearson coefficient

*: Statistically significant at $p \le 0.05$

Table 8. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in sediment, Rashid (Egypt) in autumn

		Pb	Cu	DDT	Chlordane	Dieldrin	Butylene
Zn	r	0.239	-0.584	0.548	-0.524	-0.517	0.115
	p	0.605	0.169	0.203	0.227	0.235	0.806
Pb	r		-0.323	0.206	-0.305	-0.120	-0.697
	p		0.480	0.658	0.506	0.797	0.082
Cu	r			-0.427	0.434	0.684	0.537
	p			0.339	0.331	0.090	0.214
DDT	r				-0.338	-0.053	0.081
	p				0.459	0.911	0.863
Chlordane	r					0.787*	-0.041
	p					0.036*	0.930
Dieldrin	r						0.139
	p						0.766

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

Table 9. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution; (Cu, Pb, Zn) in sediment, Rashid (Egypt) in Winter

		Pb	Cu	DDT	Chlordane	Dieldrin	Butylene
Zn	r	-0.227	-0.298	-0.120	0.158	0.579	-0.483
	p	0.624	0.516	0.798	0.735	0.173	0.272
Pb	r		0.113	-0.804*	-0.877*	-0.313	-0.406
	p		0.810	0.029*	0.010*	0.494	0.366
Cu	r			0.047	-0.219	0.139	0.032
	p			0.921	0.636	0.766	0.946
DDT	r				0.587	0.274	0.276
	p				0.165	0.551	0.550
Chlordane	r					0.204	0.553
	p					0.660	0.198
Dieldrin	r						-0.642
	p						0.120

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

Table 10. Comparison between the four studied seasons during the year (2016 - 2017) according to different parameters, organic (DDT, Chlordane, Dieldrin, butylene) and inorganic pollution (Cu, Pb, Zn) in sediment, Rashid (Egypt) in Summer

		Pb	Cu	DDT	Chlordane	Dieldrin	Butylene
Zn	r	-0.711	-0.330	0.049	-0.006	0.340	-0.214
	p	0.074	0.470	0.917	0.989	0.456	0.646
Pb	r		-0.406	-0.340	-0.350	-0.329	-0.318
	p		0.367	0.456	0.442	0.472	0.487
Cu	r			0.524	0.560	-0.198	0.552
	p			0.227	0.191	0.670	0.199
DDT	r				0.780*	-0.425	-0.006
	p				0.039*	0.341	0.990
Chlordane	r					-0.059	0.417
	p					0.900	0.352
Dieldrin	r						0.488
	p						0.267

r: Pearson coefficient

*: Statistically significant at $p \leq 0.05$

REFERENCES

1. Marchi, B., Burlando, B., Panfoli, I., Viarengo, A. 2000. Interference of heavy metal cations with fluorescent Ca2+ probes does not affect Ca2+ measurements in living cells. Cell Calcium. Oct. 28(4), 225-31.
2. Al-Yakoob, S. 1990. Influences of particulate associated petroleum conversion products on the interactions of trace metals with Kuwait marine sediments. Ph.D. dissertation, Univ. of Michigan, Ann. Arbor, Michigan.
3. Siung-Chang, A. 1997. A review of marine pollution issues in the Caribbean. Environ. Geochem. Health, 19, 45-55.
4. Scanes, P. R., and Roach, A. C. 1999. Determining natural background concentrations of trace metals in oysters from NSW, Australia. Envirol. poll.105, 437-446.
5. MacFarlane, G. R. 2001. Mangroves and pollution. In: Wolanski, E. (Ed.), Mangroves: An Ecosystem between Land and Sea. Filander Press, Furth, Germany, 153-169.
6. MacFarlane, G. R., Markich, S. J., Linz, K., Giffords Dustan, R. H., O'Conner, W., and Russell, R. A. 2005. The A'Koya pearl Oyster shell as an archival monitor of lead exposure. Environ. Poll. 143, 166-173.
7. Barron, M. G., and WoodBurn, K. B. 1995. Ecotoxicology of chlorpyrifos. Rev. Environ. Contam. Toxicol. 144, 1-93.
8. Shukla, K. P., Singh, N. K., and Sharma, S. 2010. Bioremediation: developments, current practices and perspectives. Genet. Eng. Biotechnol. J. 3, 1-20.
9. Damalas, C. A. 2009. Understanding benefits and risks of pesticide use. Sci. Res. Essays. 4, 945-949.
10. Agrawal, A., Pandey, R. S., and Sharma, B. 2010. Water pollution with special reference to pesticide contamination in India. J. Water Res. Protec. 2, 432-448.
11. Grube, A., Donaldson, D., Kiely, T., and Wu, L. 2011 Pesticides industry sales and usage: 2006 and 2007 Market Estimates. U.S. Environmental Protection Agency; Washington, D.C., United States of America. 1-33.
12. Damalas, C. A., and Eleftherohorinos, I. G. 2011. Pesticide exposure, safety issues, and risk assessment indicators. Int. J. Environ. Res. Public Health 8, 1402-1419.
13. EPA 2012. What is a Pesticide? [On line]. http://www.epa.gov/opp00001/about/. 16/07/2012.
14. Klerks, P. L., Xie, L., and Levinton, J. S. 2011. Quantitative genetics approaches to study evolutionary processes in ecotoxicology; a perspective from research on the evolution of resistance. Ecotoxicol. 20, 513-523.
15. Chevillard, A., Coussy, H. A., Guillard, V., Gontard, N., and Gastaldi, E. 2012. Investigating the biodegradation pattern of an ecofriendly pesticide delivery system based on wheat gluten and organically modified montmorillonites. Polym. Degrad. Stabil. 97, 2060-2068.

16. IRAC. Resistance management for sustainable agriculture and improved public health; 2013. (http://www.irac-online.org/).
17. Van Leeuwen, T., Vontas, J., Tsagkarakou, A., Dermauw, W., and Tirry, L. 2010. Acaricide resistance mechanisms in the two-spotted spider mite Tetranychus urticae and other important Acari: A review. Insect Biochemistry and Molecular Biology, 40, 563-572.
18. Gondhalekar, A. D., Scherer, C. W., Saran, R. K., Scharf, M. E. 2013. Implementation of an indoxacarb susceptibility monitoring program using field-collected German cockroach isolates from the United States. J. Eco. Entomol., 106, 945–953.
19. Dhaliwal, G. S., Singh, R., and Chhillar, B. S. 2006. In: Essentials of agricultural entomology. Kalyani Publishers, New Delhi, India.
20. Bernhard, M. 1976. Sampling and analysis of biological material. Manual of methods in aquatic environment research. FAO Fish. Tech. Pap. 158 (pt3), 124 p.
21. El-Moselhy, Kh. M., and Yassien, M. H. 2005. Accumulation patterns on heavy metals in venus clams, Paphia undulate (Born, 1780) and Gafrarium pectinatum (Linnaeus, 1758), from Lake Timsah, Suez Canal, Egypt. Egypt. J. Aqua. Res., 31(1), 13-28.
22. Belal, A. A. M. 1995. Ecological studies on macrobenthic invertebrates, in the intertidal zone of the Suez region. M.Sc. Thesis, Faculty of Science Suez Canal University, 215 pp.
23. Shriadah, M. A. 1992. Trace elements concentrations in the fish samples from Alexandria region. HIPH, 12(13). 437-444
24. Zyadah, M., Ibrahim, M., and Madkour, A. 2004. Impact of environmental parameters on benthic invertebrates and zooplankton biodiversity of the Eastern region of Delta coast at Damietta, Egypt. Egypt. J. Aquat. Biol. And Fish., 8 (4), 37-52.
25. Singh, B. R. and Steinnes, E. 1994. Soil and water contamination by heavy metals, p. 233-272. In: R. Lal and BA Stewart (eds.) Soil processes and water quality. Lewis, Boca Raton, Florida.
26. Frias-Espericueta, M. G., Ortiz-Arellano, M. A.., Isidro Osuna-Lopez, J. I., and Ronson-Paulin, J. A. 1999. Heavy metals in the rock oyster Crassostrea iridescens (Filibranchia: Osteridae) from Mazatlan, Sinaloa, Mexico, Revista De Biologia Tropical. 47(4), 843-850.
27. Nessim, R. B., Masoud, M. S. and Maximous, N. N. 2005. Water characteristics of Alexandria Hot spots. Egy. J. Aqua. Res. 31. special Issue. 25-37.
28. El-Rayis, O. A., and Abd Allah, M. A. 2005. Contribution of some trace elements from an Egyptian huge drain to the Mediterranean sea, west of Alexandria. Egyptian Journal of aquatic Research. 31, 120-129.
29. Abou-Taleb, A. E. A., Akel, M. M., Nessim, R. B., and Ramadan, M. H. 2004. Assessment of some heavy metals and their Accumulation in Marine Organisms in Alexandria coastal Environment, Master thesis, High Institute of Public Health, Alexandria University 260p.
30. Attia, S. I., El-Mofty, M. M., Hilmy, M. H., Marei, A. M., and Osman, M. A. 1987. Pathological effects of wastes of some factories on some water fauna in Alexandria, M.Sc Thesis
31. Ramadan, Sh. E., Kheirallah, A. M., and Abdel-Salam, Kh. M. 2006. Factors controlling marine fouling in some Alexandria Harbour, Egypt. Mediterranean Marine Science, 712, 31-54.
32. U.S. EPA. 2005. Guidelines for Carcinogen Risk Assessment. 70 FR 17765-17817
33. Aboul-Dahab, O. M. 1985. Chemical cycle of inorganic pollutants in the ecosystem west of Alexandria between Anfoushy and Agamy Ph.D. Thesis, Fac. Sci., Alexandria University.
34. Shriadah, M. A., and Emara, H. I. 1992. Iron, Manganese, Nickel, lead and cadmium in fish and crustacea from the Eastern Harbour and El-Mex Bay of Alexandria. HIPH, 21 (3), 515-25.
35. Alexandrial General Organization for Sanitary Drainge (1993)
36. El-Rayis, O. A., and El-Sabrouti, M. A. 1998. Lake Maryout: Pollution problems and proposals for restoration. Fresenius. Environ. Bull. 6, 598-604.
37. Mahmoud, A. D., Farag, E. A., El-Sherief, S. S., and Abd Ellah, Sh. M., 1999. Trace metals in the rocky shore mussel, Mytilus minimus, from Alexandria, Egypt. J. Egypt. Ger. Soc. Zool. Vol. 30 (D). Invert. Zool. and Parasit., 13-27.

38. APHA (American Public Helth Association) 1989. Standard methods for the examination of water and wastewater, 17th ed. APHA Washington, DC: Ameriacn Public Health Association, American Water Works Association and Water Pollution Control Federation.

39. Shakweer, L. M., Shiridah, M., Fahmi, M., and Abd El Fatah, A. 2006. Distribution and concentrations of trace elements along the Mediterranean coastal water of Egypt. Egyptian J. of Aquatic Research. 32 (2), 95-127.

40. Khaled, A. 1997. A comparative study for distribution of some heavy metals in aquatic organisms fished from Alexandria region. Ph.D. Thesis, Fac. Sci. Alex. Univ. 217 p.

41. Prokop, Z., Vangheluwe, M. L., Van Sprang, P. A., Janssen, C. R., and Holoubek, I. 2003. Mobility and toxicity of metals in sandy sediments deposited on land. Ecotoxicol. Environ. Saf., 54, 65-73.

42. Al-Turki, A. L., and Helal, M. I. 2004. Mobilization of Pb, Zn, Cu, and Cd in polluted soil. Pak. J. Biol. Sci., 7, 1972-1980.

43. Abdul Nabi, B. M., Adham, Kh. G., Sheweita, S. A., and Ibrahim, H. M. 2002. Xenobiotics and the susceptibility of Oreochromis niloticus (Linnaeus, 1757) from lake Maryut to environmental interactions and Hepatic Biotransformations. M.Sc. Thesis. Faculty of Sci. Univ. of Alex.

44. Samir, A. M., and Badr El-Din, A., 2001. Benthic foraminiferal assemblages and morphological abnormalities as pollution proxies in two Egyptian bays: Marine Micropaleneotology 41, 193-227.

45. Nasr, S. M. 1995. Geochemistry and granulometric normalization for heavy metals in the bottom sediments off Alexandria, Egypt. Proceeding of the 2nd Conference on the Mediterranean coasted environment. MEDCOAST 95. Tarragona. Spain. 1995, 1473-81.

46. Pangos, A., Kritsotakis, K., and Varnavas, S. 1992. Metal pollution in the Heli Bay, Greece. Rapp. Comm. Int. Mer. Mediate. 32 40-51.

47. Tomazelli, A. C., Martinelli, L. A., Avelar, W. E. P., de Camargo, P.B., Fostier, A. H., Ferraz, E. S. B., Krug, F. J., and Junior, D. S. 2003. Biomonitoring of Pb and Cd in two Impacted Watersheds in Southeast Brazil Using the Freshwater Mussel Mycetopodidae) as a biological Monitor. Brazilian archives of Biology and Technology. 46 (4), 673-684.

48. Martinez, J. 2004. Practical Guideline on Environmentally Sound Management of Obsolete Pesticides in the Latin America and Caribbean Countries. Basel Convention Coordinating Centre for Latin America and the Caribbean, Montevideo, Uruguay. 65 pp.

49. Karstensen, K. H., Nguyen, K. K., Le, B. T., Pham, H. V., Nguyen, D. T., Doan, T. T., Nguyen, H. H., Tao, M. Q., Uong, D. H., and Doan, H. T. 2006. Environmentally sound destruction of obsolete pesticides in developing countries using cement kilns. Environ. Sci. Policy. 9, 577-586.

50. Shah, B. P., and Devkota, B. 2009. Obsolete Pesticides: Their Environmental and Human Health Hazards. J. Agr. Envir. 10, 51-56.

51. Dasgupta, S., Meisner, C., and Wheeler, D. 2010. Stockpiles of obsolete pesticides and cleanup priorities: A methodology and application for Tunisia. J. Environ. Manage. 91, 824-830.

52. Ortiz-Hernández, M. L., Sánchez-Salinas, E., Olvera-Velona, A. and Folch-Mallol, J. L. 2011. Pesticides in the Environment: Impacts and its Biodegradation as a Strategy for Residues Treatment. En: Pesticides-Formulations, Effects, Fate. (M. Stoytcheva, Ed.). In Tech. Croatia, pp. 551-574.

53. Vijgen, J., and Egenhofer, C., 2009. Obsolete pesticides a ticking time bomb and why we have to act now. Centre for European Policy Studies and the International HCH & Pesticides Association. Brussels, Belgium. 28 pp.

54. Farrera, P. R. 2004. Acerca de los plaguicidas y su uso en la agricultura. Ceniap Hoy. 6. [On line]. www.ceniap.gov.ve/ceniaphoy/articulos/n6/arti/farrera_r/arti/farrera_r.htm. 20/03/2012.

55. Pan-Germany, 2012. Pesticide and health hazards. Facts and figures; 1-16 (www.pan germany.org/download/Vergift_EN-201112-web.pdf) (accessed on 14 October 2013).

56. Rosell, G., Quero, C., Coll, J., and Guerrero, A. 2008. Biorational insecticides in pest management. J. Pest. Sci., 33, 103-121.

57. Carriger, J. F., and, G. M., Gardinali, P. R., Perry, W. B., Tompkins, M. S., and Fernandez, A. M. 2006. Pesticides of potential ecological concern in sediment from South Florida canals: an ecological risk prioritization for aquatic arthropods. Soil and Sediment Contamination 2006, 15, 21-45.

58. Goldstein, M. I., Lacher, T. E., Woodbridge, B., Bechard, M. J., et al., 1999. Monocrotophos induced mass mortality of Swainson's hawks in Argentina, 1995–96. Ecotoxicology 8 (3), 201–214.

59. Schmidt, C. W. 2006. Putting the earth in play: environmental awareness and sports. Environ. Health Perspect. A 114 (5), 286–295.

60. Van-Engelsdorp, D. N., Speybroeck, J. D., Evans, et al., 2010. Weighing risk factors associated with bee colony collapse disorder by classifi cation and regression tree analysis. J. Econ. Entomol. 103 (5), 1517–1523.

61. Henry, M., Beguin, M., Requier, F. et al., 2012. A common pesticide decreases foraging success and survival in honey bees. Science 336 (6079), 348–350.

62. Farooqui, T. 2013. A potential link among biogenic amines-based pesticides, learning and memory and colony collapse disorder: a unique hypothesis. Neurochem. Int. 62 (1), 122–136 (2013) M.E. Watanabe, Colony collapse disorder: many suspects, no smoking gun. Bioscience 58 (5), 384–388.

63. Dunbabin, V. M., Airey, M., Diggle, A. J., Renton, M., Rengel, Z., Armstrong, R., Y., Chen, Y. and Siddique, K. H. M. 2011. Simulating the interaction between plant roots, soil water and nutrient flows and barriers and objects in soil using ROOTMAP. In 19th International Conference on Modelling and Simulation, Perth, Australia, 12–16 December, 2011. Retrieved from http://mssanz.org.au/modsim2011

64. Solomon, K. R., Williams, W. M., Mackay, D., Purdy, J., Giddings, J. M., and Giesy, J. P. 2014. Properties and uses of chlorpyrifos in the United States. Rev. Environ. Contam. Toxicol., 231, 13–34.

65. U.S. EPA. 2004. Guidelines for Water Reuse. NTIS PB2005 106542

66. Solomon, K. R., Giesy, J. P., Kendall, R. J., Best, L. B., Coats, J. R., Dixon, K. R., Hooper, M. J., Kenaga, E. E., and McMurry, S. T. 2001. Chlorpyrifos: ecotoxicological risk assessment for birds and mammals in corn agroecosystems. Human Ecol. Risk Assess., 7, 497–632

67. Cutler, G. C., Purdy, J., Giesy, J. P., and Solomon, K. R. 2014. Risk to pollinators from the use of chlorpyrifos in the United States. Rev. Environ. Contam. Toxicol., 231, 219–265.

68. Moore, D. R. J., Teed, R. S., Greer, C., Solomon, K. R., and Giesy, J. P. 2014. Refined avian risk assessment for chlorpyrifos in the United States. Rev. Environ. Contam. Toxicol., 231, 163–217.

69. Giddings, J. M., Williams, W. M., Solomon, K. R., and Giesy, J. P. 2014. Risks to aquatic organisms from the use of chlorpyrifos in the United States. Rev. Environ. Contam. Toxicol., 231, 119–162.

70. Williams, W. M., Giddings, J. M., Purdy, J., Solomon, K. R., and Giesy, J. P. 2014. Exposures of aquatic organisms to the organophosphorus insecticide, chlorpyrifos resulting from use in the United States. Rev. Environ. Contam. Toxicol., 231, 77–118.

71. Racke, K. D. 1993. Environmental fate of chlorpyrifos. Rev. Environ. Contam. Toxicol., 131, 1-150.