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LEVELS OF SOME HEAVY METALS IN FISH CAUGHT FROM RIVER NILE AT ASSIUT GOVERNORATE, EGYPT

(With 4 Tables and 1 Figure)

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مستوى بعض المعادن الثقيلة فى أسماك نهر النيل فى محافظة أسيوط ـ مصر

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تسببت الثورة الصناعية والتقدم الصناعى الذى صاحبها والعديد من الأنشطة الانسانية التى واكبت الصناعات المختلفة من تلوث البيئة والنظام البيئى بصفة عامة والمياه بصفة خاصة ومن المؤكد أن لهذه الملوثات أضرار جسيمة على الكائنات الحية الموجودة فى هذه المياه وعلى رأسها الأسماك أولا وعلى المستهلكين لهذه الأسماك الملوثة ثانيا . تعد المعادن الثقيلة من أهم الملوثات التى تتعرض لها البيئة المائية مما دفعنا فى هذا البحث الى تحديد مستويات الرصاص والنحاس والزئبق والكادميوم كأمثلة لهذه الملوثات المعدنية فى الأسماك التى تعيش فى هذه المياه وكذلك محاولة إيجاد علاقات بين تركيز هذه الملوثات ونوع الأسماك المستخدمة وكذلك الفصول المختلفة للعام . أجريت هذه الدراسة على ١٠٠ عينة من الأسماك تم جمعها من خمس مناطق من نهر النيل فى محافظة أسيوط وهى مدينة أسيوط (الوليدية) ومنقباد وأبوتيج وبنى قرة وديروط كما هو مبين فى الخريطة المرفقة بالبحث . تم جمع ٥ عينات من كل من البلطى والقرموط من كل منطقة وذلك فى فصلى الشتاء والصيف ، وتم قياس تركيز كل من الرصاص والنحاس والزئبق والكادميوم فى كل من هذه العينات بعد معاملتها كيميائيا . بفحص عينات الأسماك وجد أن أعلى تركيز للرصاص فى العضلات قد سجل فى أسماك القرموط فى منطقة أسيوط والذى بلغ ١ر٧٨٠ جزء فى المليون ، أثبت البحث أن كمية الرصاص الموجودة فى عضلات الأسماك فى جميع المناطق محل الاختبار قد سجلت معدلات أقل من المسموح به من قبل منظمة الصحة العالمية وهو ٢ر٦٢ جزء فى المليون. وجد أن تركيز النحاس فى عضلات الأسماك ١٥ر٩٣ جزء فى المليون فى منطقة منقباد وقد وجد أن تركيز النحاس فى عضلات الأسماك التى جمعت من مناطق أسيوط ، منقباد وبنى قرة قد تعدت الحد المسموح به عالميا وهو ١٠ جزء فى المليون . سجل

البحث أن تركيزات الزئبق والكادميوم فى عضلات الأسماك المختبرة فى جميع المناطق محل البحث أقل من الحد المسموح به عالميا وهو ٥ر٠ جزء فى المليون بالنسبة لكلا العنصرين . تعد الأسماك ملوثة فى خلال فترة البحث فى مناطق أسيوط (الوليدية) ومنقباد وبنى قرة بمعدن النحاس مما يعد مصدرا خطيرا لوصول هذه الملوثات الى أجسام المستهلكين لهذه الأسماك مما قد يؤدى الى آثار مهلكة لهؤلاء المستهلكين لها على المدى الطويل .

SUMMARY

As a result of industrial activities, the aquatic ecosystem has been increasingly contaminated by heavy metals. This posses great stresses to aquatic organisms in particular and to the whole ecosystem in general. Investigation of heavy metal concentrations in fish and water compartment of the environment are an important aspect of the control of environmental pollution to counteract the human activities which progressively increase heavy metal concentration in the aquatic system. 100 fish samples, were collected from five regions at Assiut Governorate (Abu-Tig, Assiut, Manqabad, Bany-Qurra and Dairut), five samples from *Oreochromis niloticus* and *Clarias lazera*, from each examined region in winter and in summer. Fish samples were digested and subjected to chemical analysis for determination of lead (Pb), copper (Cu), mercury (Hg) and cadmium (Cd) by using specific ion electrodes. The highest average concentration of lead in fish was 1.780 ppm in muscles. The examined muscle samples for lead showed values less than the permissible limit which is 2.62 ppm. The highest average concentration of copper in fish muscles was 15.93 ppm. Muscle samples collected from Assiut, Manqabad and Bany-Qurra exceed the permissible limit of WHO which is 10 ppm. The highest average concentration of mercury in fish muscles was 24.00 ppb. The examined muscle samples for mercury showed values less than the permissible limit which is 0.5 ppm. Cadmium showed its highest concentration in muscles as 0.658 ppm. All muscle samples showed cadmium values less than the permissible limit of WHO which is 0.5 ppm. Besides, it was found that the fish samples collected from Assiut, Manquabad and Bany-Qurra during summer and winter 1992/1993 were highly polluted with copper.

***Keywords:** Heavy metals in fish caught from River Nile at Assiut*

INTRODUCTION

It is well known that heavy metals have a great ecological significance due to their toxicity and accumulative behaviour playing a prominent role in marine environment with a tendency to accumulate in organism from different trophic levels of the marine webs (*AMIARD et al., 1987* and *Stoeppler, 1992*). *EL-NABAWI et al. (1987)* studied the concentration of lead in fish from Alexandria region, Egypt. They found that level of lead in muscle tissue of Tilapia nilotica fish caught from lake Maryut was 0.42 ppm. The levels of copper on fish muscles taken from Abu-Qir Bay were 6.9-10.2 mg/kg dry weight. The residue level of copper in Tilapia nilotica flesh was 15.4 ppm in fish caught from Idku and Maryut lakes. The average levels of mercury residues were generally low in muscle tissues of Tilapia nilotica from Idku and Maryut Lakes (0.05 mg/kg). The concentration of cadmium in muscle tissues ranged from 0.018-0.023 ppm in fish from both Abu-Qir Bay and Idku and Maryut Lakes.

AMAL (1993) studied the concentration of some heavy metals in some freshwater fishes caught from different localities at Assiut Governorate, she found that lead concentration was 7.31, 7.36, 6.94, 5.94 and 8.04 ppm in El-Mateha, Assiut, El-Walidea, Salaam and Manqabad in winter and 4.98, 7.20, 5.98, 6.92 and 5.88 ppm in summer respectively. It was found that the level of copper in freshwater fish was 19.52, 12.86, 7.78, 6.57 and 8.58 ppm in winter and 15.30, 11.13, 11.88, 9.97 and 11.13 ppm in summer at El-Mateha, Assiut, El-Walidea, Salaam and Manqabad respectively. The level of cadmium in freshwater fish was 0.389, 0.326, 0.340, 0.293, and 0.323 ppm in winter and 0.299, 0.325, 0.381, 0.359 and 0.354 ppm in summer at El-Moteha, Assiut, El-Walidea, Salaam and Manqabad respectively.

Since man will probably depend more and more upon protein from marine sources in the future as fish accounts for 25% of the total meat consumed by man in the world, the aim of this paper was to assess the levels of some heavy metals in fish samples caught from different localities in Assiut Governorate during winter and summer 1992/1993. Comparison between these levels and the limits recommended by the international organizations dealing with the public health was also our goal. Finally, we tried to find out if there is a correlation between metal concentration and each of the species and the season.

MATERIALS and METHODS

A) *Fish:*

A total number of one hundred fish samples investigated in this study collected from Abu-Tig, El-Walidya (Assiut), Manquabad, Bany-Qurra and Dairut during winter and summer 1992/1993 as shwon in Fig. 1. Half of these samples were from Nile tilapia, *Oreochromis niloticus* and the rest from catfish, *Clarias lazera* species (five fish from each species, region and season). The body weight of *Oreochromis niloticus* fish was ranged from 250-400 g and that of *Clarias lazera* was 400-500 g. All fish samples were subjected to clinical and postmortem examination to detect any apparent toxic manifestations or postmortem lesions.

B) *Preparation of Samples:*

Samples of muscles were collected from all examined fish and deeply frozen at – 20°C till time of analysis. They were digested according to the method of Koirtyohann et al. (1982) as follow: Two grams of muscle were placed in clean, dry 100 ml kjeldahl flask and 10 ml purified nitric acid was added. Samples were heated gently until the appearance of brownish fumes, heating was continued till the volume reached 2-3 ml in 90-120 minute. Complete digestion was indicated by the disappearance of the liquid colour. The digest was diluted with bidistilled water and adjusted to 50 ml in volumetric flask.

C) *Estimation of heavy metals:*

Estimation of lead was adopted according to the method of *CAMPIGLIO (1979)*; copper (*SMITH AND MANAHAN, 1973*), mercury (*OVERMAN, 1971*) and cadmium (*GARDINER* and *MANCE, 1984*).

D) Statistical analysis:

Data were statistically analyzed according to *KALTON (1967)*. Multiple correlation was obtained by programming system according to PC state, the University of Georgia, Athens, Georgia, in the Computer Center of Assiut University.

RESULTS

Lead levels in *Oreochromis niloticus* fish muscles showed that the highest average levels were recorded at the areas of Abu-Tig and Assiut (1.740 and 0.920 ppm) in winter, while in summer the highest average levels of (0.580, 0.400 ppm) were observed at Dairut and Bany-Qurra as shown in Table 1.

Meanwhile, lead contents in muscles of *Clarias lazera* fish recorded its highest average levels at areas of Assiut and Manqabad (1.780 and 0.740 ppm) in winter, while in summer the highest average levels recorded at Abu-Tig and Dairut were 0.630 and 0.520 ppm, Table 2.

Analysis of copper level in muscle of *O. niloticus* fish reached its highest average levels at areas of Assiut and Manqabad (11.818 and 9.334 ppm) in winter, while in summer the levels of copper elevated at Manqabad and Bany-Qurra (15.930 and 11.982 ppm respectively).

In muscles of *C. lazera* fish the highest average levels of copper were recorded at areas of Manqabad and Dairut either in winter (8.835 and 7.179 ppm) or in summer (10.179 and 9.909 ppm).

In muscles of O. niloticus fish, the highest average levels of mercury in winter were recorded at areas of Manqabad, Abu-Tig and Bany-Qurra (2.170, 2.010 and 1.010 ppb respectively), while in summer the levels of mercury elevated at Bany-Qurra, Manqabad and Dairut (24.000, 6.580 and 6.500 ppb respectively).

In muscles of *C. lazera* fish the highest average levels of mercury were recorded at areas of Abu-Tig and Bany-Qurra (22.300 and 11.300 ppb) in winter, while in summer mercury was elevated at Dairut, Bany-Qurra and Manqabad (10.300, 8.600 and 8.300 ppb respectively).

Analysis of muscles of *O. niloticus* fish for cadmium revealed its highest average levels at Abu-Tig and Bany-Qurra (0.070 and 0.045 ppm respectively) in winter, while in summer the highest values were recorded at Bany-Qurra and Manqabad (0.150 and 0.049 ppm respectively).

In muscles of *C. lazera* fish the highest average levels of cadmium were recoat areas of Assiut and Abu-Tig (0.560 and 0.290 ppm) in winter. While in summer the highest average values of cadmium were shown at Manqabad and Bany-Qurra fish (0.189 and 0.127 ppm).

Correlation between fish species and element concentrations was summarized in Table 3. In *Clarias lazera*, the correlation between elements revealed a negative correlation between lead and both copper and mercury, and highly negative correlation between lead and cadmium. A highly positive correlation between copper and mercury and positive correlation between copper and cadmium were observed. In *Oreochromis niloticus*, a highly negative correlation between lead and copper, on the other hand a highly positive correlation between copper and cadmium was observed. A highly positive correlation between lead element in the two studied species of fish, and a highly negative correlation between lead and both copper and cadmium. There was a highly positive correlation of copper in the two species of fish, meanwhile, highly positive correlation between copper and both mercury and cadmium. On the other hand, a highly negative correlation between copper and lead. Such results revealed a high positive correlation between mercury in the two fish species and between it in one hand and copper and cadmium on the other hand.

Correlation between the effects of season variation on the elemental status revealed that, in winter the correlation between elements showed a highly negative correlation between lead and copper. On the other hand, a highly positive correlation between lead and both mercury and cadmium was found. A highly negative correlation between copper and both mercury and cadmium was also observed. There was a highly positive correlation between mercury and cadmium. In summer season, lead was negatively correlated with copper, mercury and cadmium, while a highly positive correlation between copper and both cadmium and mercury as well as between mercury and cadmium. Elemental status clarified a highly positive correlation between lead element in the two seasons and a highly negative correlation between lead and copper, mercury and cadmium. On the other hand, copper content was highly negative correlated with lead, while copper was significantly positive correlated with either mercury or cadmium. A highly positive correlation between copper element in the two seasons was observed. Mercury was highly positive correlated with lead, while mercury was highly negative correlated with either copper or cadmium, also mercury content was highly negative correlated in the two seasons. There was positive correlation between cadmium and lead, while negative correlation between cadmium and both copper and mercury was detected (Table, 4).

DISCUSSION

Chemicals discharged into an aquatic system are distributed within the soluble phase, the suspended or bottom sediments, and in biota (*CONNELL, 1987*). This complex process is governed not only by the physico-chemical properties of the chemicals, but also by hydrological, weathering and geological factors (*GESAMP, 1987*), With trace metals, only a small proportion remains in the soluble fraction, while the major fraction is removed and becomes associated with the suspended or bottom sediments (*LUOMA, 1988*). According to *DE GREGORI et al. (1994)*, it is well known that heavy metals have a great ecological significance due to their toxicity and accumulative behavior playing a prominent role in aquatic ecosystems.

They occur in all compartments in aquatic environment with tendency to accumulate in organism from different trophic levels of aquatic webs. Along this pathway, toxic heavy metal becomes a potential hazard for man, aquatic birds and mammals. The study of macroenvironmental components, water and aquatic weeds is the most important step in evaluation of pollution and its hazardous effects to man and animal. According to *AHMED et al. (1993)*, fishery products are contaminated with appreciable amounts of potentially hazardous contaminants. Inorganic contaminants with the greatest potential for toxicity are lead, cadmium, mercury and copper. These contaminants pose potential risk for consumers.

The ranges and mean concentrations of lead, copper, mercury and cadmium in muscles of *Oreochromis niloticus* are reported in Table 1. The highest average of lead level in muscles reported at Abu-Tig and Assiut (1.740 and 0.920 ppm) in winter, Dairut and Bany-Qurra (0.580 and 0.400 ppm) in summer. Heavy metal concentrations in muscles of *Clarias lazera* are reported in table 2. The highest amount of lead in muscle samples were recorded at Assiut and Manqabad (1.780 and 0.740 ppm) in winter, and Abu-Tig and Dairut (0.630 and 0.520 ppm) in summer. *EL-NABAWI et al. (1987)* stated that lead residues in muscle tissue usually lower than these in organs. *BARAK* and *MASON (1990)* recorded that lead levels were several times higher in liver than flesh. Investigated muscle samples were lower than the permissible limit (2.62 ppm) reported by *DREISBACH* and *ROBERTSON (1987)*. The present study revealed that lead concentration in fish samples were higher than that recorded by *EL-NABAWI et al. (1987)* during their study of lead concentration in muscle tissues of *Tilapia nilotica* fish in Idku and Maryut lakes in Egypt. The present findings are considered higher than results obtained by *BARAK and MASON (1990)* in their study of the level of lead residues in both liver and muscle tissue of freshwater fish in Eastern England which reached 0.11 and 0.09 ppm respectively and our results considered lower than the results obtained by *AMAL (1993)* in her study for detecting lead residues in fish caught from River Nile at Assiut region, which ranged between 4.98 - 8.04 ppm in muscles. It is not easy to compare the present results with data reported in the literature because of the particular characteristics of each aquatic system, as well as the methodologies employed during the collection, preservation and analysis of samples.

The levels of lead concentration in muscle tissue of fish caught from River Nile in Assiut governorate were lower than the permissible limit during the time of sample collection in both winter and summer. The highest average amount of copper in muscle recorded at Assiut and Manqabad

(11.818 and 9.334 ppm) in winter and Manqabad and Bany-Qurra (15.930 and 11.982 ppm) in summer. The highest average amount of copper in muscles showed at Manqabad and Dairut either in winter (8.835 and 7.179 ppm) or in summer (10.179 and 9.909 ppm). Manqabad and El-Walidia at Assiut city are more valnerable to anthropogenic pollution with toxic metals and it must be kept in mind that these areas have high seafood production and fishing activities. Comparing the results found in muscles with the permissible limit (10 ppm) reported by *REICHENB'ACH-KLINKE (1974)* it was higher than such limit in *Oreochromis niloticus* at Assiut in winter and at Manqabad and Bany-Qurra in summer season, while in *Clarias lazera* it exceed the permissible limit only in summer at Manqabad area.

Regarding copper concentrations it was revealed an elevation of copper level in *Oreochromis niloticus* muscles in comparison to *Clarias lazera*. These findings contradict that of Hassan and Youssef (1985) who reported that copper concentration in muscles of *Clarias lazera* (12.0 ppm) was higher than that of Tilapia (6.00 ppm). Our results were in agreement with that obtained by *EL-NABAWI et al. (1987)* of *Tilapia nilotica* caught from Idku and Maryut Lakes (15.4 ppm) and were in harmony with the results obtained by *AMAL (1993)* who detected the level of copper residues in muscle tissue of fish caught from River Nile at Assiut region during 1989. The presence of high levels of copper in fish muscles could be attributed to the explanation of *McCONCHIE and LAWRANCE (1991)* who stated that taking into account the high acidity of the digestive systems in most aquatic organisms, the effective load of trace metals absorbed by biota would exceed the levels present in solution.

The highest average amount of mercury in muscle of *Oreochromis niloticus* recorded at Manqabad and Abu-Tig (2.170 and 2.010 ppb) in winter sewhile Bany-Qurra and Manqabad (24.0 and 6.580 ppb) in summer. The highest average amount of mercury in muscles of *Clarias lazera* recorded at Abu-Tig and Bany-Qurra (22.300 and 11.300 ppb) in winter and Dairut and Bany-Qurra (10.300 and 8.600 ppb) in summer. Fish accumulate mercury directly from food and the surrounding water *(BRYAN, 1976 AND RAINBOW, 1985)* and mercury bioaccumulates by predation (Staveland et al., 1993). Further mercury is transformed to a very toxic, organic form, methyl mercury in aquatic sediments. Organic mercury is taken up 15 times more readily than inorganic mercury (*RIISGARD and HANSEN, 1990*). In many studies mercury was monitored as a hazardous toxic substances to fish, however, in these studies little attention was paid to the possible effects of season and/or species on the pollutant levels. The present study revealed that the level of mercury residues was higher in summer than in winter and in *Oreochromis niloticus* than in *Clarias lazera*. Furthermore, mercury level was less than the permissible limit (0.5 ppm) of the National Academy of *SCIENCE (1972)*, and the results obtained by El-Nabawi et al. (1987) in his investigation of Idku and Maryut Lakes in Egypt as well as that obtained by *BARAK and MASON (1990)* in freshwater fish of Brett River in England.

The highest concentration of cadmium in muscles of *Oreochromis niloticus* were registered in samples collected from Abu-Tig and Bany-Qurra (0.070 and 0.045 ppm) in winter and Bany-Qurra and Manqabad (0.150 and 0.049 ppm) in summer. The highest average of cadmium concentration in muscles of *Clarias lazera* reported in Assiut and Abu-Tig (0.560 and 0.290 ppm) in winter and Manqabad and Bany-Qurra (0.189 and 0.127 ppm) in summer. Cadmium levels in the muscles of investigated fish in the selected areas were lower than the permissible limit (0.5 ppm) of *National Academy of Sciences (1972)*, only the samples of winter from *Clarias lazera* at Assiut slightly exceeds that of National Academy of Science which is 0.560 ppm. Previous literatures reported a higher cadmium levels in fish muscles of Assiut province as *HASSAN and YOUSSEF (1985)* who obtained levels of 0.39 and 1.48 ppm of cadmium in *Tilapia nilotica* and *Clarias lazera* respectively. The present results were higher than that obtained by *EL-NABAWI et al. (1987)* who found that cadmium levels in flesh of *Tilapia nilotica* was 0.018 ppm as well as *BARAK and MASON (1990)* who stated that cadmium levels in freshwater fish were 0.05 and 0.4 ppm in muscle and liver respectively. The present findings were in harmony with that obtained by *AMAL (1993)*, who determined cadmium level in fish flesh caught from River Nile in Assiut which ranged from 0.293 and 0.389 ppm.

In spite of a lot of work has been done in the estimation of heavy metals in fish, few attention was given to the species difference, Table 3, of proved the species difference between *Oreochromis niloticus* and *Clarias lazera* in case of cadmium concentration. Some fish species tend to accumulate or concentrate heavy metals such as cadmium. *HASSAN and YOUSSEF (1985)* demonstrated a species differences between *Tilapia nilotica* and *Clarias lazera* in case of copper and cadmium concentrations. *STAVELAND et al. (1993)* reported a species differences between flounder and cod in mercury and arsenic accumulation and they attributed these differences to feeding and behavior habit between these species.

In the present study seasonal variations are proved as a factor of heavy metal concentrations. Table 4 summarized the correlation between season and the heavy metal concentrations. In *Oreochromis niloticus* a variable amount of copper, mercury and cadmium was registered from winter to summer. These variations may be attributed to seasonal habit and feeds which differ from winter to summer. In *Clarias lazera* there was a negative correlation of mercury and cadmium contents between winter and summer seasons. The effect of season on elemental contents in both *Oreochromis niloticus* and *Clarias lazera* revealed a negative correlation in mercuric and cadmium content in the two species, these results clarified the effect of the season as an important factor in the concentration of some heavy metals in fish. *BARAK and MASON (1990)* found that there is a seasonal variation in mercury and cadmium and lead concentrations in Eels flesh and liver caught from Eastern England rivers. They attributed this variation to the feeding habit as eels in winter cease feeding and stay buried in the mud, sediment contain more metallic concentration. *STAVELAND et al. (1993)* studied the effect of seasonal variation on flounder and cod fish caught from Norway bitches and found that arsenic and mercury concentrations differ from season to another and they attributed these variations to the migration habit and season of maturation.

Finally, it could be concluded that River Nile which is the main source of life in Egypt is polluted with lead and mercury in some areas along its course in Assiut Governorate such as El-Walidya, Manqubad, Abu-Tig, Bany-Qurra, and Dairut. This contamination could be attributed to several factories and large number of garbage dump which situated along its course in the tested areas. Cadmium is the second source of contamination of Nile water in Manqabad and Dairut. Ranges and mean concentration of copper in Nile water during the time of sampling were within the limits reported by the public health organizations. A programme should be developed for current monitoring of heavy metals in aquatic environment of the River Nile.

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Table (1): Heavy metal concentrations in muscles of Oreochromis niloticus fish muscles

Areas of sampling		Winter Lead (ppm)	Winter Copper (ppm)	Winter Mercury (ppb)	Winter Cadmium (ppm)	Summer Lead (ppm)	Summer Copper (ppm)	Summer Mercury (ppb)	Summer Cadmium (ppm)
Abu-Tig	mean±S.E*.	1.740±0.180	1.050± .288	2.010±0.130	0.070±0.110	0.290±0.040	3.204± .708	0.540±0.010	0.021±0.004
	range	1.420-2.350	0.62-2.170	1.700-2.480	0.106-0.830	0.160-0.490	1.620-6.345	0.270-0.810	0.012-0.033
Assiut	mean ± S.E.	0.920±0.090	11.818±1.857	0.580±0.080	0.038±0.005	0.290±0.030	2.122± .981	2.020±0.180	0.028±0.005
	range	0.680-1.200	5.425-12.550	0.310-0.770	0.018-0.057	0.170-0.370	0.945-6.480	1.350-2.560	0.014-0.049
Manqabad	mean ± S.E.	0.350± .030	9.334±1.661	2.170±0.150	0.022±0.001	0.210±0.010	15.93± .450	6.580±0.340	0.049±0.0006
	range	0.240-0.510	5.89-15.810	1.550-2.630	0.017-0.026	0.140-0.240	14.85-17.550	5.940-8.100	00.047-0.051
Bany-Qurra	mean ± S.E.	0.200±0.010	4.002± .610	1.010±0.041	0.045±0.002	0.400±0.050	11.982± .615	24.000±3.100	0.150±0.027
	range	0.150-0.260	2.32-6.380	0.870-1.160	0.034-0.052	0.220-0.510	12.69-13.365	12.100-33.700	0.097-0.256
Dairut	mean ± S.E.	0.140±0.010	3.949±.749	0.490±0.051	0.018±0.002	0.580± .040	4.85± .660	6.500±0.280	0.017±0.001
	range	0.100-0.180	0.875-5.950	0.290-0.580	0.014-0.031	0.430-0.670	2.15-6.200	5.670-7.290	0.013-0.025

* S.E.: Standard Error

Table (2): Heavy metal concentrations in muscles of Clarias lazera fish

Areas		Winter				Summer			
		Lead (ppm)	Copper (ppm)	Mercury (ppb)	Cadmium (ppm)	Lead (ppm)	Copper (ppm)	Mercury (ppb)	Cadmium (ppm)
Abu-Tig	mean±S.E*.	0.460± .030	0.409± .090	22.300±1.110	0.290±0.049	0.630±0.080	4.341± .743	0.450±0.048	0.064±0.008
	range	0.310-0.540	0.170- .651	18.600-26.300	0.200-0.490	0.430-0.870	2.970-7.560	0.270-0.540	0.054-0.100
Assiut	mean ± S.E.	1.780±0.090	1.057± .0138	0.460±0.043	0.560±0.039	0.180±0.010	8.370± .437	0.670± .066	0.054±0.002
	range	1.480-2.010	0.527-1.162	0.310-0.620	0.380-0.620	0.130-0.220	7.290-9.585	0.540-0.945	0.045-0.062
Manqabad	mean ± S.E.	0.740±0.020	8.835± .440	2.170±0.220	0.023±0.001	0.250±0.020	10.179±1.038	8.300±0.820	0.189±0.010
	range	0.650-0.820	6.975-9.765	1.550-2.940	0.015-0.026	0.180-0.330	6.750-12.825	6.480-11.400	0.056-0.221
Bany-Qurra	mean ± S.E.	0.260± .010	3.037±0.475	11.300±1.140	0.037±0.006	0.120±0.009	9.045± .628	8.600±0.760	0.127±0.010
	range	0.210-0.330	1.740-4.640	0.870-13.740	0.014-0.055	0.100-0.160	7.155-10.66	6.340-11.070	0.108-0.162
Dairut	mean ± S.E.	0.200± .0090	7.179± .522	0.720±0.110	0.031±0.003	0.520±0.090	9.909± .799	10.300±0.710	0.082±0.017
	range	0.170-0.230	5.945-9.570	0.430-1.160	0.023-0.043	0.320-0.910	6.885-11.745	8.370-12.200	0.032-0.135

* S.E.: Standard Error

Table (3): Correlation between estimated heavy metal and species of fish

Fish / Heavy metal		Clarias lazera				Oreochromis niloticus			
		Lead (Pb)	Copper (Cu)	Mercury (Hg)	Cadmium (Cd)	Lead (Pb)	Copper (Cu)	Mercury (Hg)	Cadmium (Cd)
Clarias lazera	Lead (Pb)	1.0000							
	Copper (Cu)	- .4801*	1.0000						
	Mercury (Hg)	- .4452*	0.8123**	1.0000					
	Cadmium (Cd)	- .8447**	0.4384*	0.2274 NS	1.0000				
Oreochromis niloticus	Lead (Pb)	0.5908**	- .7198**	- .3963*	- .5266**	1.0000			
	Copper (Cu)	- .6988**	0.7773**	0.5710**	0.6367**	- .8586**	1.0000		
	Mercury (Hg)	- .0469 NS	0.7650**	0.7112**	- .0141 NS	- .3830 NS	0.3349 NS	1.0000	
	Cadmium (Cd)	- .5398**	0.5168**	0.7152**	0.2899 NS	- .3588 NS	0.6509**	0.2371 NS	1.0000

NS : Not significant
* : Significant at P<0.05
** : Significant at P<0.01

Table (4): Correlation between heavy metal concentration and the season

Season / Heavy metal		Winter				Summer			
		Lead (Pb)	**Copper (Cu)**	**Mercury (Hg)**	**Cadmium (Cd)**	**Lead (Pb)**	**Copper (Cu)**	**Mercury (Hg)**	**Cadmium (Cd)**
Winter	**Lead (Pb)**	1.0000							
	Copper (Cu)	- .6521**	1.0000						
	Mercury (Hg)	0.7203**	- .8062**	1.0000					
	Cadmium (Cd)	0.6027**	- .7461**	0.6729**	1.0000				
Summer	**Lead (Pb)**	0.8865**	- .5380**	0.6573**	0.4241*	1.0000			
	Copper (Cu)	- .8240**	0.5406**	- .5202**	- .4937*	- .7869**	1.0000		
	Mercury (Hg)	- .6215**	0.8031**	- .5847**	- .8447**	- .4459*	0.6647**	1.0000	
	Cadmium (Cd)	- .6565**	0.6124**	- .5745**	- .3472 NS	- .7817**	0.7315**	0.5458**	1.0000

NS : Not significant
* : Significant at P<0.05
** : Significant at P<0.01

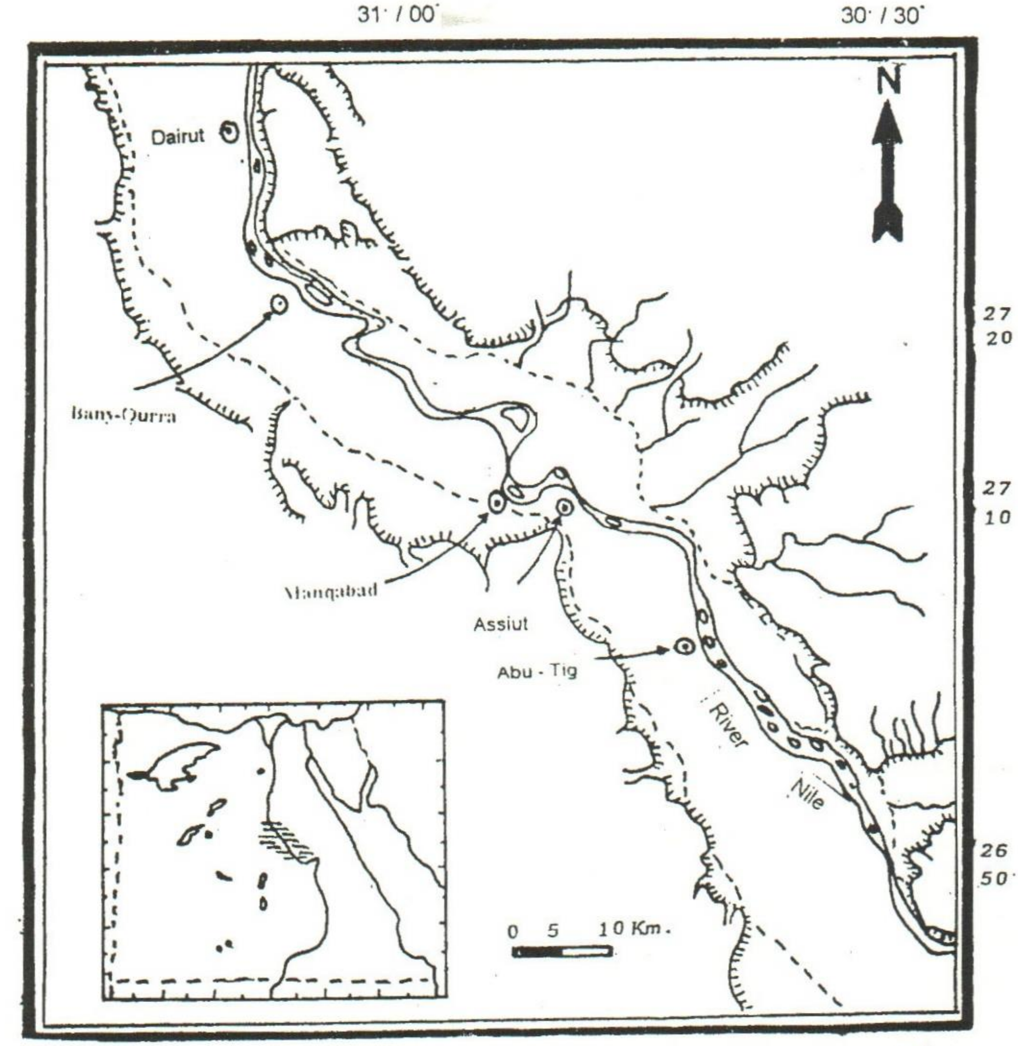

Fig. 1. location map of studied areas