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Assessment of environmental toxicity in Iraqi Southern marshes using fish as bio-indicators

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A moderate level of pollution with petroleum hydrocarbons and traces of heavy metals has been detected in some sites of the Al-Hammar marshes. Lower levels were also found in the Al-Huwaiza marsh. Fish (Himri, *Barbus luteus*) in the possibly polluted area gave signs for unhealthy environment by accumulating higher levels of pollutants in their muscles and gonads as compared with those monitored in the more healthy area. Disturbance in the age structure of the fish population was also recorded, with the dominance of certain length groups and ages in the polluted areas. A delay in gonad maturation and disturbance of sex ratio were noticed in the stations with higher levels of pollutants. A remarkable increase in metabolic enzymes which suppose to work in liver was noted in the fish inhabiting the polluted area. The biochemical constitutes of blood serum were found to be altered in the polluted areas with a decrease in total protein, albumin and cholesterol concentrations indicating a possible case of loosing blood to the tissues or inefficiency in liver function. It is concluded that fish conditions in some parts of the Al-Hammar marsh indicate the unhealthy environment which is obvious by some physiological responses due to the presence of pollutants. There is an urgent need to set up a long-term programme of research and a monitoring system to assess the pollution status in the newly flooded marshes. Further histological and bio-markers studies are strongly recommended.

Key words: hydrocarbons, heavy metals, toxicity, fish, Iraqi marshes

INTRODUCTION

The Iraqi freshwater environment, in general, and the southern marshy habitats in particular suffered from various types of pollution especially that related to pesticides, hydrocarbons or heavy metal toxicants. A higher chemical pollution in the marshes and rivers was previously reported (DouAbul et al., 1988; Saeed et al., 1999). The levels of pollution in marshes have increased substantially in recent years (Al-Imarah et al., 2006). Both biotic and abiotic factors can adversely be affected by the presence of toxicants even in trace concentrations. The introduction of motor boats to the deeper areas of the marshes has led to noticeable and frequent oil pollution along the heavily used waterways between the main villages. The distribution of polycyclic aromatic hydrocarbons (PAHs) in the Al-Hammar marsh sediments was studied by Al-Saad and Al-Timari (1989).

In addition to their fatal effect on aquatic organisms, toxicants may directly or indirectly affect human health. This may reflect the vital importance of the early alert system for detection and permanent monitoring of these harmful substances in natural water bodies. The uncontrolled flooding of marshes now presents potential problems and challenges regarding the quality of water because of the release of toxins from reflooded soils that are contaminated with chemicals from mines and military ordnance (Richardson, Hussein, 2006). According to Richardson et al. (2005), the analysis of surface water and soils for organochlorin pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons (PAHs) showed no detectable concentrations of any of these xenobiotics. However, recent surveys in the Abu Zarag marsh have showed low molecular weights of PAHs in the Abu Zarag soils, probably as a result of the severe burnings in the region (DouAbul et al., 2005).

Fish are known to be the living organisms, most sensitive to trace concentrations of toxicants in the aquatic habitats. Chemicals such as hydrocarbons and heavy metals would probably act as endocrine disrupters causing degeneration in some gonadal tissues, which led to

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a delay in gonadal maturation and reduction in gonad weight. Biological toxicity tests on age structure (length frequency, age groups and condition factor), in addition to the measurements of blood biochemical constituents such as serum protein, albumin, globulin, glucose and cholesterol (Tierney, Forrell, 2004) and metabolic enzymes such as GOT, GPT, ALP, LDH, CK (Luskova et al., 2002) could lead to an early detection of ecotoxicity in the waters of the Southern marshes of Iraq.The present project aims at finding an early alarm system to detect the toxicity of marsh waters, using biomarkers in fish. Three tasks were investigated:

1. The present levels of hydrocarbons and heavy metals in water, sediments and fish flesh.
2. The effect of possible environmental toxicity on fish age structure and maturation status.
3. Monitoring some sub-organismal bio-markers such as metabolic enzymes and other biochemical constituents in blood serum.

STUDY AREA

To achieve the above objectives, four stations were selected in three different marshes of Southern Iraq (Fig. 1). Two stations (Al-Bargah and Al-Nagarah) were chosen in the Al-Hammar marsh. They represented unpolluted and possibly polluted areas respectively, depending on previous reports (Al-Imarah et al., 2005), with an intensive fishing activity. The third station (Al-Bagdadia) is located in the Chebayesh marsh (West Hammar) and represents a polluted site. The fourth station is located in the Huwaiza marsh (Um Al-Ward) where urban and fishing activities are concentrated. The description, GPS locations and date of visiting the four stations are shown in Table 1.

MATERIALS AND METHODS

Sampling

Sampling included water, sediments and fish. Large samples of water (20 l) were collected at each station, with a clean amber-glass bottle of 5 litre capacity. Samples of Himri fish, *Barbus luteus*, were either purchased fresh from the nearby fish market or caught by hired fishermen using electro-fishing which is a widely spread fishing method in the marshes. The samples were kept refrigerated in polyethene boxes with ice during transport to the laboratory. They were stored in the fridge till further analysis.

Analysis of hydrocarbons and heavy metals

Hydrocarbons in water were solvent- extracted following the procedure of UNESCO (1976), using the ultraviolet fluorescence (UVF) analysis. Concentrations of trace metals in water samples are usually determined with an atomic absorption spectrophotometer (type SP9 Pye-Unicam) after certain analytical processes according to the methods of Sturgeon et al. (1982).

Upon arrival to the laboratory, fish were dissected, and samples of muscles and gonads were taken for analysis. The extraction of a fish sample was done according to the method described by DouAbul et al. (1997). Analysis of total petroleum hydrocarbons (TPH) was conducted by means of the ultraviolet fluorescence (UVF) technique. Analysis of trace metals was performed on the <63 μm fraction of the fish muscle samples separated by sieving after drying and grinding. The determination of trace metals was done according to the procedure described by Sturgeon et al. (1982) using atomic absorption type SP9 Pye Unicom.

Analysis of fish population structure

To examine the effect of toxicants on fish population structure, the following parameters were determined: age structure, condition factor (CF), gonad weight (Gonosomatic Index GSI) and maturation age.

The age structure was determined by the scale method and the length frequency technique, both being outlined by the FAO stock assessment guideline.

The condition factor (CF) was calculated from the formula:

$$100\ W / L^3,$$

where W is the weight (g), L is the length cm).

Gonadal maturity was assessed by examining the morphology of ovaries and testes, using the index of maturity stages by Lagler (1971). For gono-somatic index, the following formula was applied:

$$GW / W,$$

where GW is gonad weight (g) and W is fish weight (g).

Table 1. **Locations and description of marsh stations and dates of sampling**

Marsh	Station	GPS	Environment	Sampling dates
West Hammar (Chebayesh)	Al-Bagdadida	N 31 07 58 E 47 03 07	Open water Sparse vegetation	10 May 2007
East Hammar	Al-Bargah	N 30 40 22 E 47 33 03	Tidal open water	3 June 2007
East Hammar	Al-Nagarah	N 30 40 52 E 47 35 12	Open water Dense vegetation	5 July 2007
Al-Huwaiza	Um Al-Ward	N 31 35 30 E 47 35 21	Open water Sparse vegetation	12 August 2007

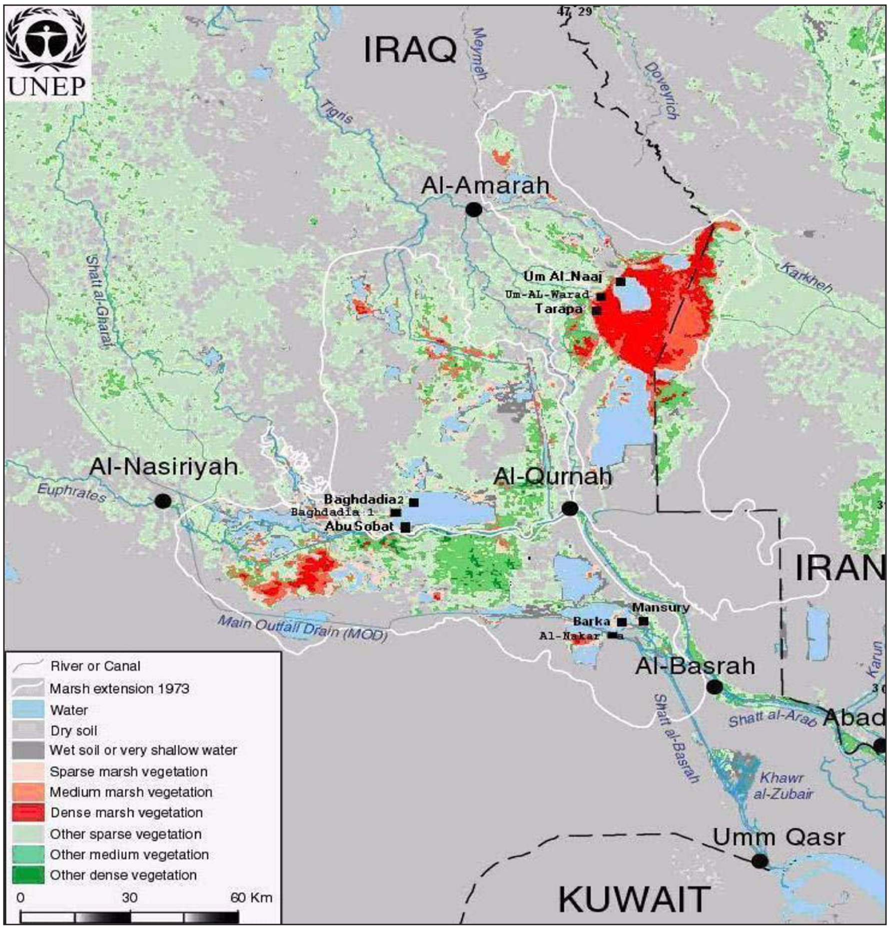

Fig. 1. The Southern marshes of Iraq with details of the sampling stations

Analysis of sub-organism bio-markers

A variety of endpoints measured at lower levels of biological organization, termed biomarkers, can be detected for the assessment of environmental toxic effects. These include biochemical, cellular and chemical endpoints such as serum enzymes and serum biochemical constituents. Samples of Himri *Barbus luteus* for serum analysis were selected of uniform weight of nearly 100 g from the catch collected from all stations. Fish were anaesthetized by a blow on the head and blood was collected in heparinized haematocrit tubes after severing the caudal peduncle vein / artery. Blood samples were then centrifuged at 1500 rpm in a micro haematocrit centrifuge unit (Model MSE 488A), plasma separated and serum samples frozen at – 4 °C till further analysis. The following blood serum enzymes were analyzed:

1. Alkaline phosphatase enzyme (ALP) was determined using a commercial kit (Biomerieux, France) according to the method of Belfield and Goldberg (1971) using a spectrophotometer at 510 nm wave length.

2. Glutamic oxaloacetic trans-aminase enzyme (GOT) was measured by a Randox kit following the method of Reitman and Frankel (1957) on a spectrophotometer at 546 nm wave length.

3. Transaminase measurement of glutamic pyruvic (GPT) was performed in blood serum with the help of a Randox kit according to the method of Reitman and Frankel (1957), using a spectrophotometer at 546 nm wave length.

4. Creatin kinase (CK) was measured with a Randox kit following the method of Allain (1974b) using a spectrophotometer at 560 nm wave length.

5. Lactate dehydrogenase enzyme (LDH) was measured by a Randox Kit following Doumas et al. (1971) using a spectrophotometer at 520 nm wave length.

Stored frozen serum samples were also used to measure the biochemical constituents of blood serum. Concentrations of blood protein (Watanabe et al., 1987), globulin (Richard and Pickering, 1979), albumin (Doumas et al., 1971), cholesterol (Allain, 1974a) and glucose (Dingeon, 1975) were measured using kits from Randox and Biomerieux and a spectrophotometer at different wave lengths.

Statistical analysis

Average and standard error values were calculated for different measurements. A statistical computer package was used for calculating probability values of Student's t-test or one-way analysis of variance to test the differences between the measurements at the level of 0.05 and 0.01.

RESULTS AND DISCUSSION

Hydrocarbons in water

According to the data presented in Table 1, two stations in the Al-Hammar marsh (Al-Bagdadia and Al-Nagarah) recorded the highest level of hydrocarbons in water (36.59 and 22.35 μg/l, respectively). The other two stations (Al-Bargah and Um Al-Ward) recorded significantly ($p < 0.05$) lower levels (16.68 and 17.43 μg/l, respectively). Hydrocarbons in water could also be associated with sediments and accumulated in 0–20 cm layer in the bottom soil along the water body. The percentage of total organic carbon (TOC) reflected nearly the same trend with Bagdadia showing the highest value followed by the Um Al-ward and the Al-Nagarah marshes (Table 2).

To compare our results with the values recorded during 2004 (Al-Imarah et al., 2006), it can be seen that the values recorded in this investigation are comparable to the ranges shown for hydrocarbons in the Al-Hammar and Al-Huwaiza marshes. Concentrations of TPH recorded in the water from Iraqi marshlands were in the range of 0.6–46.82, 20.48–39.87, 14.28–26.16 and 11.78–17.45 μg / l during all seasons. Reported values indicate that the Al-Hammar marshland is rich in petroleum hydrocarbons as compared with other marshes except the Um Al-Ward which is located in the entrance of the Al-Huwaiza marshland and recorded also to have a high level of TPHs. The values in both studies almost are within the normal limits for freshwater environment (less than 50 μg / l). The levels of TPH reported in the present study, however, are within the safe limits of human usage, as recommended by the World Health Organization (WHO). There are two factors affecting the variation of petroleum hydrocarbons in water of the Southern Iraqi marshlands, namely temperature and water flow. It seems that the phenomenon of water flow is the more effective factor governing the random variation of petroleum hydrocarbons in the Southern Iraqi marshlands more than seasonal temperature variations (DouAbul, Al-Saad, 1985).

Heavy metals in water

Heavy metals are natural constituents of all environments. They occur in traces, normally at the nanogram to microgram per litre, in all aquatic ecosystems including freshwater habitats. The concentrations of heavy metals, reported in our study for the water and sediments of the four sites in the Al-Hammar and Al-Huwaiza marshes, are presented in Table 3. It appeared that values are within the ranges recorded previously by Al-Saad et al. (2009) in the Southern marshes water, which are as follows: Co (1.13–3.68), Mn (0.16–1.37), Ni (0.66–2.37), Fe (0.28–1.51), Cu (0.10–0.28) mg / l.

It has been found that Al-Bagdadia and Al-Nagarah sites of the Al-Hammar marsh contained higher levels of heavy metals in water than the other two stations. Lower but insignificant ($p > 0.05$) values were recorded at Um Al-Ward site in the Al-Huwaiza marsh. Al-Bargah in the Al-Hammar marsh recorded the lowest concentrations which are significantly ($p < 0.05$) different from the other stations (Table 3). Trace metals enter the Southern Iraqi marshes from both natural and anthropogenic sources (Abaychi, Al-Saad, 1988). Natural sources include dust fall, erosion or crusted weathering and dead decomposition of the biota in the water; whereas the anthropogenic sources include sewage wastes, pesticides and fertilizers coming through irrigation and industrial effluent.

Hydrocarbons in fish muscles and gonads

The data presented in Table 4 shows the total concentrations of hydrocarbons (TPH) in the muscles and gonads of Himri *B. luteus* collected from different sites in the Al-Hammar and Al-Huwaiza marshes. Fish, collected from Bagdadia and Nagarah in the Al-Hammar marsh, contained the highest levels of TPH, corresponding with the values recorded in the water and sediments of these marshes. Lower values of TPH were observed in fishes collected from Um Al-Ward station in the Huwaiza marsh (Table 3). Fish from the Al-Bargah marsh recorded the lowest TPH concentration in muscles and gonads. That might be due to a better water quality of the region.

Table 2. **Average concentrations of total percentage concentrations of total petroleum hydrocarbons (TPH) ± SE and the percentage of total organic carbon (TOC) in the water of different stations**

Stations	TPH μg/l	TOC %
Um Al-Ward	17.43 ± 3.23	0.92
Al-Bagdadia	36.59 ± 5.64	1.24
Al-Nagarah	22.35 ± 1.04	0.67
Al-Bargah	16.68 ± 1.69	0.47

Table 3. **Average concentrations (mg / l) ± SE of some heavy metals in the marsh water**

Cu	Fe	Ni	Mn	Co	Stations
0.18 ± 0.01	1.02 ± 0.06	2.51 ± 0.93	0.17 ± 0.002	1.25 ± 0.02	Um Al-Ward
0.22 ± 0.03	1.55 ± 0.06	1.27 ± 0.08	0.43 ± 0.06	2.76 ± 0.13	Al-Bagdadia
0.14 ± 0.02	0.51 ± 0.09	1.38 ± 0.11	0.19 ± 0.005	3.69 ± 0.78	Al-Nagarah
0.15 ± 0.004	0.32 ± 0.02	0.70 ± 0.03	1.42 ± 0.008	1.32 ± 0.06	Al-Bargah

Table 4. **The range of total petroleum hydrocarbons (TPH) in the muscles and gonads of Himri *Barbus luteus***

Stations	TPH in muscles µg / g dry wt.	TPH in gonads µg / g dry wt.
Um Al-Ward	2.46–3.23	2.01–2.30
Al-Bagdadia	4.79–6.87	2.23–2.73
Al-Nagarah	3.31–3.60	1.05–1.58
Al-Bargah	1.51–2.76	0.56–0.91

Values of the present investigation are comparable to concentrations previously reported in the Shatt Al-Arab River (Al-Saad, Al-Asadi, 1989; Al-Saad, 1995) and other freshwater habitats. In fish of all stations, the muscles contained significantly higher concentrations of TPH than gonads, which is a normal phenomenon in fish. The effect of TPH, however, is more serious on gonads. Sexual maturity, spermato- and ovo-genesis are seriously affected by the traces of hydrocarbons in gonads.

Heavy metals in muscles and gonads

As we can see from the contents of Table 5, the traces of certain heavy metals (such as, Pb, Fe, Mn and Co) occurred in higher amounts in the muscles and gonads of Himri from Al-the Nagarah marsh. Fish from Bagdadia and Um Al-Ward showed moderate levels, whereas the Bargah fish contained the lowest levels of heavy metals. Apart from the Nagarah readings, all other values are within the range previously reported in fish.

The effect of toxicants on fish population structure

Length frequency distribution and condition factor

Analysis of length frequency distribution of fish collected from the three stations in Al-Hammar Marsh are presented in Table 6 and Fig. 2. It is obvious that, groups ranging in length between 15–25 cm are dominent in all stations. However, in the possibly polluted one (Al-Bagdadia), only fish of 15–25 cm are present in the randomly collected sample. This means that there is an unbalanced population structure, compared with the other two stations (Bargah & Nagarah). Another indicator, which shows the degree of wellbeing of fish, is the condition factor (CF: ratio of W/L3). Values of CF

Table 5. **Concentration of heavy metals (µg / g) dry weight in muscles and gonads of Himri *Barbus luteus* collected from the chosen stations**

Station	Co	Mn	Ni	Fe	Cd	Pb	Zn
Muscles							
Um Al-Ward	0.89± 0.03	2.48± 0.07	1.02± 0.003	54.08± 8.35	ND	6.72± 0.64	9.54± 3.36
Al-Bagdadia	1.64± 0.01	1.58± 0.04	2.32± 0.70	47.54± 5.79	ND	3.80± 0.22	8.86± 1.28
Al-Nagarah	2.12± 0.01	5.11± 0.52	3.02± 0.87	80.20± 7.84	1.01± 0.002	12.56± 3.25	11.48± 1.68
Al-Bargah	0.47 ± 0.001	1.36± 0.09	0.66± 0.005	10.79± 1.65	ND	ND	1.25± 0.04
Gonads							
Um Al-Ward	0.77± 0.06	2.01± 0.09	0.87± 0.03	57.24± 8.34	0.20± 0.005	ND	9.55± 1.2
Al-Bagdadia	1.01± 0.002	1.28± 0.02	1.52± 0.006	44.15± 3.84	ND	0.72± 0.06	10.27± 2.54
Al-Nagarah	1.86± 0.05	2.77± 0.56	2.02± 0.03	70.1 0± 5.45	1.01± 0.003	1.45± 0.06	15.25± 1.80
Al-Bargah	ND	1.36± 0.04	0.56± 0.10	10.79± 1.96	ND	ND	3.12± 0.11

Table 6. **Length frequency and condition factor of Himri *Barbus luteus* in three stations of the Al-Hammar and the Chebayesh marshes**

Length group (cm)	No. of fish	Mean length (cm)	Mean wt. (g)	CF
		Al-Bargah		
10–15	2	13.3	40.1	1.704
15–20	6	16.9	86.8	1.795
20–25	10	21.6	163.0	1.617
25–30	2	27.5	370.2	1.780
		Al-Nagarah		
10–15	3	13.7	37.2	1.447
15–20	10	17.4	92.3	1.670
20–25	10	21.5	166.0	1.670
		Al-Bagdadia		
15–20	2	19.5	108.2	1.459
20–25	11	21.7	152.8	1.495

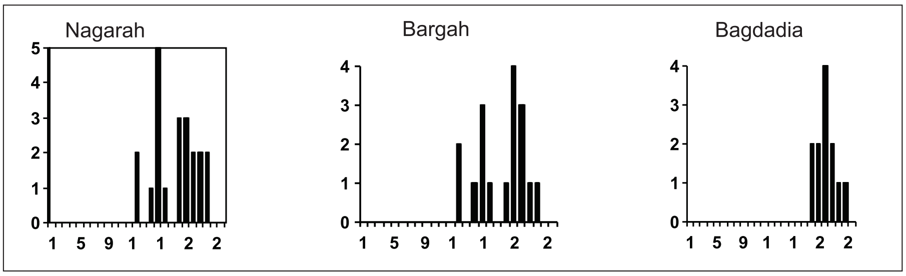

Fig. 2. Length frequency distribution of ***Barbus luteus*** in the Al-Hammar marsh
X-axis: total length (cm) Y-axis: No. of fish

Table 7. **Age structure of Himri *Barbus luteus* in three stations of Al-Hammar and Chebayesh marshes**

Age (years)	No. of fish	Mean length (cm)	Mean weight (g)
Al-Bargah			
2	3	14.3	51
3	9	18.5	119
4	3	21.5	160
5	1	23.8	169
6	2	27.5	370
Al-Nagarah			
2	8	15.8	61
3	7	20.1	119
4	5	21.9	180
5	1	23.0	241
Al-Bagdadia			
3	4	20.5	119
4	7	22.5	156
5	2	23.5	197

Table 8. **Gonadal weight and Gono-somatic index of Himri Barbus luteus in three stations of Al-Hammar and Chebayesh marshes**

T.L.	Wt. (g)	Sex	Gonad wt. (g)	GSI
Al-Bargah				
14.5	45.6	M	0.93	2.04
17.6	83.3	M	1.29	1.55
19.3	157.4	M	1.20	0.76
20.8	159.1	M	1.38	0.86
21.6	168.3	M	1.46	0.86
28.6	345	M	1.62	0.46
21.0	155.2	F	1.41	0.91
22.6	178.2	F	4.52	2.54
23.6	201.1	F	3.62	1.80
27.0	378	F	7.02	1.86
Al-Nagarah				
17.5	83	M	1.26	1.52
18.7	169	M	1.16	0.68
21.2	158	M	1.40	0.88
23.6	241	M	2.65	1.09
21.8	168	F	1.52	0.90
22.5	175	F	6.15	3.51
Al-Bagdadia				
19.5	103	M	0.53	0.51
20.2	116	M	0.86	0.74
20.2	125	M	0.91	0.73
21.6	150	M	0.89	0.59
22.0	158	M	0.97	0.61
22.3	163	M	1.15	0.71
24.1	220	M	1.47	0.67

are presented in Table 6. It can be seen that growth of Himri in weight in Al-Bargah station (CF 1.704–1.780) is better than that in Al-Bagdadia (CF 1.459–1.495) as they exhibited heavier weight for their length and consequently higher CF values.

Age structure

The same picture has been reflected by the data of age structure as another indicator. Fish age structure in the Al-Bargah station comprises five age groups ranging within 2–6 years, while that of Al-Bagdadia shows only three groups (3, 4 and 5 years). Besides, fish of the same age was heavier in weight in Bargah and Nagarah than in Bagdadia. Age of fish from Nagarah station ranged from 2–5 years with comparatively suitable weight (Table 7). The presence of pollutants in Al-Bagdadia marsh have adversely been reflected on the popu lation structure of fish and to a less extent upon fish of the Al-Nagarah station. In comparison, fish, inhabiting the Al-Bargah, seemed to have a fairly normal structure.

Gonadal maturity

Fish in all sites showed a low degree of immaturity due to the late spawning season.The sampling was accidently performed beyond spawning season of Himri, which is between February and May in Southern Iraq. Nevertheless, the data of Table 8 showed clearly the differences in gonad maturation of fish living in the three stations. Fish in the Al-Bargah marsh had better GSI values which is (0.72–2.04) for 6 males and (0.91–2.54) for 4 females compared with those of the Al-Bagdadia marsh, where the GSI ranged from (0.59–0.74) for males only as not a single female was present in the sample. In the Al-Nagarah marsh, the GSI values ranged from 0.68–1.52 in males and 0.9–3.51 in females with a sex ratio of 4 males : 3 females. Many fishes in the samples of the three stations were immature, with an indefinite GSI. A comparatively high level of pollutants in the Al-Baghdadia waters and sediments impose the direct biological responses on gonad maturation and sex ratio which appeared in favour of the male side.

In the Al-Bargah fish, a half of the examined Himri was in a certain stage of maturity, where a half of the body cavity was occupied by the gonads, which had a pinkish color.

The other half had gonads of whitish color, occupying ¼ of the body cavity. This might be considered as a normal stage in such period of the spawning season.

In Al-Bagdadia fish, all examined gonads were found to occupy only ¼ or less of the body cavity with a cloudy whitish color in an undifferentiated stage, giving the impression of the abnormal sexual maturity status. The gonads from the Al-Nagarah fish (one male and one female) were found to occupy a half of the body cavity, the two ¼ of it and 2 appeared as filamentous immature structures.

The effect of toxicants on the bio-markers of the sub-organism

The effect on biochemical constituents of blood serum. Table 9 summarizes the data obtained by analyzing the biochemical constituents of blood serum of Himri fish collected from three stations of the Al-Hammar and Huwaiza marshes. Variations in biochemical constituents of blood represent some of the physiological responses of fish towards the alteration in environmental factors such as pollutants, toxicants and pathogens in aquatic habitats (Tierney, Forrell, 2004).

It has been noted, that concentrations of serum protein and albumin were lower than normal in the blood of Himri from the Al-Bagdadia marsh (3.01 and 1.80 mg / 100 ml), compared with the data of fish collected from the Al-Bargah marsh (4.20 and 3.16 mg / 100 ml, respectively). Histologically, this may be explained on basis of losing blood toward tissues, or a decrease in liver efficiency (Anderson, 2001). The concentration of globulin on the other hand, has increased due to the immune response toward the toxicity or disease infection in the more polluted stations. Ratio of albumin to globulin is important for checking suitability of the environmental factors. This ratio was significantly reduced ($p < 0.05$) in fish collected from the Al-Bagdadia and Al-Nagarah marshes possibly due to increased levels of hydrocarbons and heavy metals, compared with fish of the Al-Bargah station. The reduction, of course, was a result of a decreased amount of albumin and increased concentration of globulin in the serum of fish inhabiting these marshes.

Another indicator on the disturbance of hepatocyte (liver cells) function is the significant decrease ($p < 0.01$) in the cholesterol concentration in the blood serum which was noted in Himri fish of the Al-Bagdadia and Um Al-Ward stations. This means that the fish can not synthesize cholesterol and pump it to the blood stream in the normal way (Rand, Munden, 1992). Other constituents, however, have not varied significantly among the tested stations ($p > 0.05$).

The effect on metabolic enzymes. The measured enzymes are working in the liver and obviously the function of the liver due to the environmental pollution has been adversely affected. This might be attributed to the environmental stress on fish, which affect the normal metabolic activities (Luskova et al., 2002; Jeney et al., 2002). Data presented in Table 10, shows an ascending trend of serum enzymes of fish, living in the possibly polluted areas (Al-Bagdadia) and to some extent in the Al-Nagarah and Um Al-Ward marshes. Significantly higher values of LDH, ALP and GOT were recorded in fish, collected from Al-Bagdadia. The value of GOT in Bagdadia fish (114 U / l) was significantly ($p < 0.05$) higher than the normal levels (23–89 U / l) in healthy fish. The same can be seen regarding the GPT, which reached a level of 9.43 U / l exceeding the range (1.6–6.4 U/l) found in normal fish serum as described by Al-Timimi (2001). LDH and CK are of particular importance in fish muscles, and their occurrence in blood serum in high levels indicates a case of tissue deteriorating (necrosis).

Table 9. **Average values of biochemical constituents of blood serum (mg / 100 ml) ± SE of Himri *Barbus luteus* from four stations in the Southern marshes of Iraq**

Constituents	Um Al-Ward	Al-Bagdadia	Al-Nagarah	Al-Bargah
Total Protein	3.27 ± 0.39	3.01 ± 0.48	3.89 ± 1.01	4.20 ± 1.31
Albumin	2.01 ± 0.07	1.80 ± 0.08	1.98 ± 0.52	3.16 ± 1.02
Globulin	1.66 ± 0.09	2.03 ± 0.33	1.91 ± 0.07	1.28 ± 0.07
Albumin / Globulin	1.21 ± 0.37	0.89 ± 0.02	1.01 ± 0.03	1.46 ± 0.04
Glucose	74.28 ± 9.76	83.92 ± 6.91	70.16 ± 5.65	66.38 ± 7.53
Cholesterol	110.2 ± 6.5	95.6 ± 8.4	116.1 ± 5.38	124.5 ± 6.43

Table 10. **Average values of metabolic enzymes in blood serum expressed as unit per litre (U / l ± SE) in Himri *Barbus luteus* collected from four stations in the Southern marshes of Iraq**

Enzyme	Um Al-Ward	Al-Bagdadia	Al-Nagarah	Al-Bargah
GOT	51.3 ± 2.8	94.7 ± 3.7	64.8 ± 6.8	48.9 ± 2.9
GPT	4.8 ± 0.02	7.4 ± 0.3	5.6 ± 1.1	4.5 ± 0.8
ALP	78.9 ± 4.6	105.4 5.3	102.4 ± 7.8	65.2 ± 2.4
LDH	95.1 ± 6.1	145.6 ± 7.7	130.7 ± 6.2	85.4 ± 6.2
CK	46.1 ± 3.9	66.3 ± 4.7	58.7 ± 4.1	39.2 ± 3.6

CONCLUSIONS

1. The present study detects moderate levels of pollution with hydrocarbons and heavy metals in the Southern Iraqi marshes.

2. Fish collected from the polluted area showed the pollutant accumulation, a delay in gonad maturation, a disturbance in age structure and the dominance of small length groups.

3. The amount of liver metabolic enzymes, acting as detoxifying agents, was found to be increased while the concentration of serum chemical constituents was detected to be decreased during summer months in fish collected from the possibly polluted areas (the Al-Bagdadia and Al-Nagarah marshes) as compared with fish of the unpolluted marsh (Al-Bargah). This might be due to the increased levels of hydrocarbons and heavy metals. Both liver enzymes and serum constituents can, accordingly, be used as biomarkers.

4. The present results approved the necessity for permanent pollution monitoring program in the Iraqi marshes using water quality criteria and fish response as indicators.

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PIETŲ IRAKO PELKIŲ APLINKOS UŽTERŠTUMO TYRIMAI PANAUDOJANT ŽUVIS KAIP BIOLOGINĮ INDIKATORIŲ

Santrauka

Tyrimų metu Al-Hamaro ir Al-Huvaizos pelkėse rasti nedideli aplinkos teršalų (naftos angliavandenilių ir sunkiųjų metalų) kiekiai. Tirtos karpinių šeimos žuvys *Barbus luteus* užterštoje aplinkoje savo raumenyse ir gonadose buvo sukaupusios kur kas daugiau teršalų, palyginus su žuvimis iš švaresnių vandenų. Labiau užterštose pelkėse rasti gonadų vystymosi sutrikimai, pakitusi žuvų populiacijos amžiaus struktūra ir lyčių santykis. Ženklus žuvų kepenų metabolinių fermentų kiekio padidėjimas nustatytas pelkėse, kuriose rasta ir didesnė teršalų koncentracija. Nustatyti kraujo serumo sudėtinių dalių pakitimai – sumažėjusi baltymų, albuminų ir cholesterolio koncentracija – rodo galimą audinių kraujavimą arba pakenktą kepenų funkciją. Tyrinėjant žuvų fiziologinį atsaką prieita išvada, kad kai kurie Al-Hamaro pelkių plotai yra stipriai užteršti, todėl būtina skubiai sukurti ilgalaikę stebėjimo sistemą, kuri padėtų nustatyti naujai užlietų pelkių plotų užterštumą. Rekomenduojami tolesni histologiniai ir biologinių žymenų tyrimai.

Raktažodžiai: angliavandeniliai, sunkieji metalai, toksiškumas, žuvys, Irako pelkės