Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 6, Issue, 04, pp.6124-6129, April, 2014

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EVALUATION OF FISH ASSEMBLAGE ENVIRONMENT IN HUWAZAH MARSH, IRAQ USING INTEGRATED BIOLOGICAL INDEX

*[1]Abdul-Razak M. Mohamed and [2]Najah A. Hussain

[1]Department of Fisheries and Marine Resources, College of Agriculture,University of Basrah, Iraq
[2]Department of Biology, College of Science, University of Basrah, Iraq

ARTICLE INFO

Article History:
Received 14th January, 2013
Received in revised form
10th February, 2014
Accepted 15th March, 2014
Published online 23rd April, 2014

Key words:
IBI, fish assemblage,
Huwazah marsh, Iraq

ABSTRACT

An Index of Biotic Integrity (IBI) was used to assess the status of the fish assemblage of Huwazah marsh, Iraq from October 2005 to September 2006. IBI scores were calculated from 14 separate assemblage metrics based on the species richness, species composition and trophic guilds. After more than two years of restoration activities and improved water quality, the state of the fish community in Huwazah marsh was fair (IBI= 53.2%), and better than the other marshes after four years of restoration. The results revealed that no substantial improvements have been recorded during the late years of restoration, reflect that the environment is still fragile and need time to be recovering.

*Copyright ©2014**Abdul-Razak M. Mohamed and Najah A. Hussain**.This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

INTRODUCTION

The marshes of southern Iraq were the largest wetlands in southwest Asia and covered surface area ranged from 3,000-4,000 km^2 during the dry-bed season to 15,000 km^2 during the flood season (Khayyat, 1957). These marshes were characterized by thickets of aquatic vegetation, generally consisting of common reed, *Phragmitesaustralis* and rushes, *Typhadomingensis* (Al-Mayah, 1992; Al-Hilli *et al.*, 2009). In 1990, FAO estimated that the total inland catch of fish in Iraq was 23600 tones, with over 60% of this coming from the Mesopotamian marshes (Partow, 2001). They were the permanent habitat for millions of birds and a flyway for millions more migrating between Siberia and Africa (Maltby, 1994; Evans, 2002). The construction of large dams and reservoirs during the last three decades in the upper basin of the Euphrates in Turkey and Syria and on the Tigris and its tributaries in Iran and Iraq have had a huge impact on basin hydrology, especially in southern marshes of Iraq. The rate of water flow in the Tigris and Euphrates between 1938 and 1973 was estimated at around 2600 m^3/s but fell below 830m^3/s in the years 1973-1998 (Al-Mowsawi, 2012). Also, the constructions of drainage systems by diversions of major rivers surrounding the marsh areas, and drainage processes in the 1990s drained the southern marshlands and led to substantial loss of native aquatic flora and fauna well-known for a long period as marsh biota of southern Iraq.

Corresponding author: Abdul-Razak M. Mohamed
Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq

In 2002, 35% of the Huwazah marshes near the Iranian border remained (Richardson and Hussain, 2006). The re-flooding of the dried marshland areas started in 2003, when local residents opened the floodgates and broke the banks to let water back from the Tigris River into the marsh (Anonymous, 2006).The Index of Biotic Integrity (IBI) provided a tool for quantifying changes in ecosystem health as a result of habitat degradation or flow alteration, in addition to chronically poor chemical water quality (Karr and Dudley, 1981). The original version of the IBI was first developed using fish in small warm water streams in central Illinois and Indiana, USA by Karr (1981). As the IBI became more widely used, different versions were developed for different regions and different ecosystems included lakes and wetlands (Minns*et al.*, 1994; Simon, 1998; Belpaire*et al.*, 2000; Simon *et al.*, 2000; Bozzetti, Schulz, 2004; Uzarski1 *et al.*, 2005; Bhaga*et al.*, 2007; Brousseau and Randall, 2008; Krause *et al.*, 2012).

Several studies have been focus on describe the fish assemblages in the southern marshes since inundation in 2003 (ARID, 2006; Hussain *et al.*, 2006, 2009; Mohamed *et al.*, 2008, 2009, 2012; Youns *et al.*, 2011). Some works have been carried out attempting to evaluate water quality change as result of environmental alteration in the marshes by using Water Quality Index, WQI or water characteristics (Al-Saboonchi *et al.*, 2011; Al-Kenzawi *et al.*, 2011) or fish structure changes in the marshes by applying the Index of Biotic Integrity, IBI (Al-Shamary, 2008; Abd, 2010; Mohamed and Hussain, 2012b).This study aims to evaluate changes in the fish assemblage of Huwazah marsh, to assess the marsh condition and to identify eventual recovery trends after two

years of inundation, in comparison to other southern marshes of Iraq.

MATERIALS AND METHODS

The Huwazah marsh lies to the east of the Tigris River, straddling the Iran-Iraq border (Fig. 1). It is 30-40 km wide, and the area covered by water during the flood season is about 3,000 km^2 with a maximum depth of 6 m (Al-Rubaiy, 1990). The marsh is largely fed by two main distributaries departing from the Tigris River near Amarah, known as Al-Musharah and Al-Zahla. Added to this is water from rainfall, and water from the rivers arriving from Iran, such as the Al-Karkha, Tayib and Duwayaraj, which empty into the Sanaf marsh and which in turn supplies the Huwazah marsh.

Fishes were collected monthly from two selected sites, Um Alnaaj and Taraba in Huwazah marsh (Fig. 1) from October 2005 to September 2006, using seine net, fixed gill nets and electro-fishing gear as explained by Mohamed *et al.* (2008). Each species was classified in respect to its geographic origin (native or alien), trophic guilds and environmental degradation tolerance (Table 1) using several fisheries publications (Hussain *et al.*, 2006; Mohamed *et al.*, 2008, 2012; Coad, 2010; Mohamed and Hussain, 2012a, b).

Table 1. Geographic origin, tolerance and trophic group of fish captured from the Huwazah marsh during 2005-2006

Family/species	Origin	Tolerance	Trophic Guild
Cyprinidae			
Carassiusauratus	Alien	Tolerance	Herbivore
Barbusluteus	Native	Sensitive	Herbivore
Acanthobramamarmid	Native	Tolerance	Carnivore
Alburnusmossulensis	Native	Tolerance	Carnivore
Cyprinuscarpio	Alien	Tolerance	Omnivore
Aspiusvorax	Native	Sensitive	Piscivore
Cyprinionmicrostmum	Native	Sensitive	Carnivore
Barbussharpeyi	Native	Sensitive	Herbivore
Barbusgrypus	Native	Sensitive	Omnivore
Barbusxanthopterus	Native	Sensitive	Omnivore
Hemiculterleucisculus	Alien	Tolerance	Herbivore
Mugilidae			
Liza abu	Native	Tolerance	Detrivore
Siluridae			
Silurustriostegus	Native	Sensitive	Piscivore
Heteropneustidae			
Heteropneustusfossilis	Alien	Tolerance	Carnivore
Mastacembelidae			
Matacembelusmatacembelus	Native	Sensitive	Piscivore

The adaptation of the IBI followed the approach of Minns*et al.* (1994), who scored metrics from 1 to 10. Scores for metrics that increase with environmental quality (numbers of native, common native fish species, proportion of sensitive native species, proportion of herbivore, proportion of carnivore and proportion of piscivore, and species richness) were standardized to a scale of 0 to 10. A value of 10 would be assigned to the highest value of each raw metrics, otherwise the standardized score was calculated as *B*x raw score, where *B* = 10/ highest value. Scores of metrics that increase with decreasing environmental quality (number and proportion of alien, and proportion of tolerance species, proportion of*Liza abu*, proportion of*Carassiusauratus*, proportion of omnivoreand proportion ofdetrivore fish) were standardized to a scale of 0 to 10. A value of 0 would be assigned to the highest value of each raw metrics, otherwise the standardized score was calculated as 1- *B*x raw score, where *B* = 10/ highest value. Standardized IBI metrics were summed to obtain an IBI score that varied continuously from 0 to 100 for the marsh and the month, for each metric. IBI scores are rated as very poor (0-20), poor (20-40), fair (40-60), good (60-80) and excellent (>80) (Minns *et al.*, 1994). The species richness index (*D*) is defined by (Margalef, 1968): *D*= *S*-1 / loge *N*, where, *S*= number of species and *N*= number of individuals.

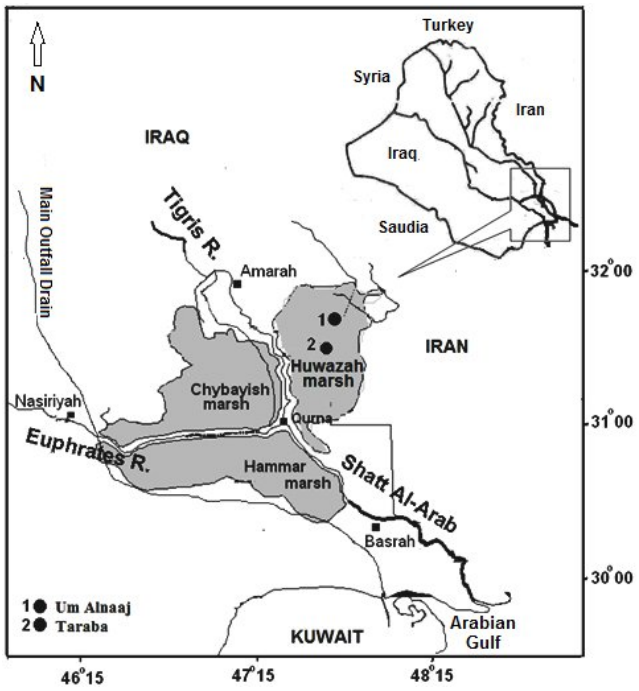

Figure 1. Map of southern of Iraq, showing the location of Huwazah marsh

RESULTS

As a result, fifteen fish species were recorded from Huwazah marsh, all of them freshwater. The monthly variations in the species composition used to calculate IBI are presented in Table 2 and the monthly fluctuations in IBI scores metrics of Huwazah marsh are illustrated in Figure 2.

Species richness metrics

The number of native fish species in the catch was eleven, constituted 73.3% of the total number of species. The highest appearance of the species was 10 in June and July, and the lowest was 4 in December. IBI score of native fish species ranged from 4% in December to 10% in June and July. The alien species was four, formed 26.7% of the total number of species. The lowest number was one in December and the highest was four in September. The highest score of alien fish species was 7.5% in December. The highest number of common native species was eight recorded in June and the lowest was three recorded in December, July and September.

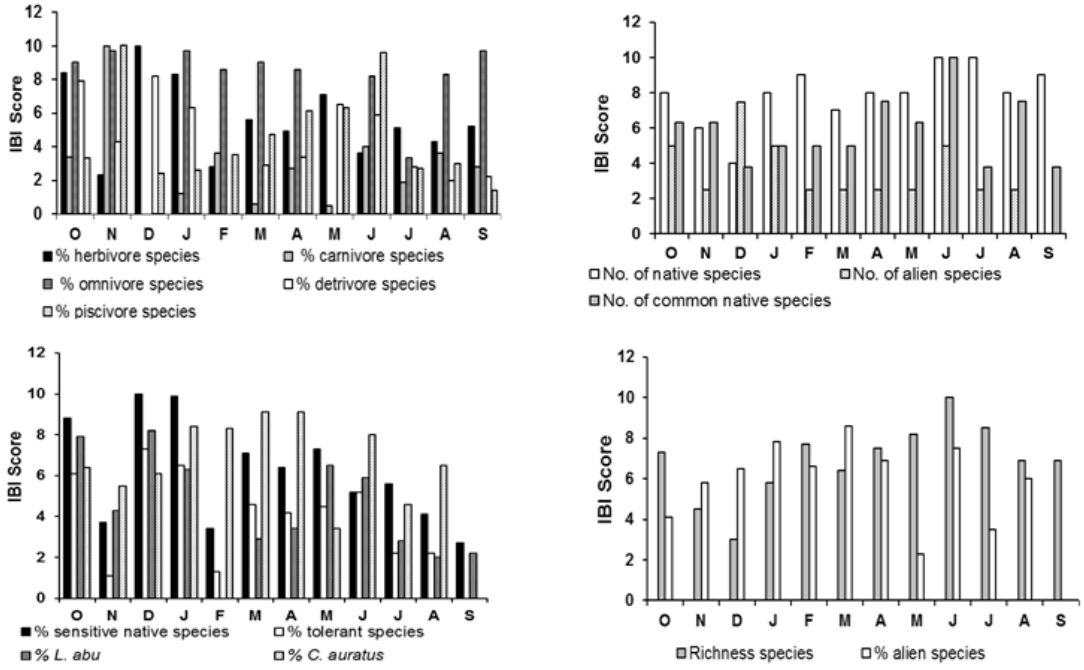

Figure 2. Monthly variations in IBI scores metrics in Huwazah marsh (2005-2006)

Table 2. Monthly variations in the fish assemblage metrics used to calculate IBI of Huwazah marsh during 2005-2006

IBI metrics	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
No. of native species	8	6	4	8	9	7	8	8	10	10	8	9
No. of alien species	2	3	1	2	3	3	3	3	2	3	3	4
No. of common native species	5	5	3	4	4	4	6	5	8	3	6	3
Proportion of alien species	20.2	14.3	12.1	7.4	11.6	4.8	10.6	26.3	8.4	22.1	13.7	34.0
Proportion of *L. abu*	12.3	33.0	10.8	21.6	58.5	41.4	38.4	20.4	24.2	41.9	46.5	45.3
Proportion of *C. auratus*	11.0	13.9	12.1	5.0	5.1	2.7	2.9	20.4	6.3	16.7	10.9	30.9
Proportion of sensitive native species	64.6	26.8	73.4	72.9	24.7	52.4	47.3	53.9	38.0	41.3	30.0	19.9
Proportion of tolerant species	33.1	76.1	22.9	29.9	74.6	46.2	49.8	47.4	41.0	67.1	66.4	85.5
Proportion of herbivores	71.1	19.2	84.8	70.1	23.7	47.4	41.6	60.5	30.6	43.6	36.4	44.0
Proportion of carnivores	9.8	28.9	0.0	3.4	10.5	1.8	7.7	1.3	11.6	5.4	10.3	8.0
Proportion of omnivores	0.6	0.2	0.0	0.2	0.9	0.6	0.8	5.9	1.1	4.0	1.0	0.2
Proportion of detrivores	12.3	33.0	10.8	21.6	58.5	41.4	38.4	20.4	24.2	41.9	46.5	45.3
Proportion of piscivores	6.1	18.6	4.4	4.8	6.5	8.7	11.5	11.8	17.9	5.1	5.7	2.5
Species richness	1.8	1.1	0.7	1.4	1.9	1.6	1.8	2.0	2.4	2.1	1.7	1.7
IBI	91.8	75.8	76.8	90.8	62.3	76	81.3	69.4	98	59.3	66.9	45.9

Table 3. Comparison of IBI scores metrics between Huwazah and other marshes

IBI metrics	Huwazah[1]	Hammar[2]	Hammar[3]	Chybaish[4]
No. of species	15	37	31	14
No. of native species	11	13	14	10
% of native species	73	35	45.2	71.4
% of native individuals	81.2	51	59.8	76.7
No. of alien species	4	9	6	4
% of alien species	27	24	19.4	28.6
% of alien individuals	18.8	42.3	29.4	23.3
No. of migratory species	0	15	11	0
% of migratory species	0	40.5	35.5	0
% of migratory individuals	0	6.5	10.8	0
% of *L. abu*	32.8	28.4	37.5	56.1
% of *C. auratus*	11.5	26.4	25.4	19.7
% of sensitive species	45.4	24.3	3.9	11.7
% of tolerant species	53.3	83.2	87.5	88.2
% of herbivores	47.7	1.2	27	23.5
% of carnivores	8.2	17.3	21.8	6.8
% of omnivores	1.3	45	11.5	1.5
% of detrivores	32.8	29.5	39.3	61.9
% of piscivores	8.6	7.0	2.3	6.4
Species richness	0.7-2.4 (1.7)	-	0.7-2.8 (1.8)	0.8-1.7 (1.3)

[1] Present study, [2] Al-Shamary (2008), [3] Mohamed and Hussain (2012), [4]Mohamed (2014)

IBI score of common native species ranged from 3.6% in December to 10% in June. The species richness of fish assemblage was varied between 0.7 in December to 2.4 in June. IBI score of species richness ranged from 3.0% in December to 10% in June (Fig. 2).

Species composition metrics

Of the total catch of 4715 fish from the Huwazah marsh, alien fish consisted 15.5% of them. The highest proportion of alien fish was 34.0% in September and the lowest (4.8%) in March. *Carassiusauratus* was the most abundant alien species, which contributed 11.5% of the total catch. IBI score of proportion alien species attained the highest value 8.6% in March. *Liza abu*was the most abundant species comprising 32.9% of the total catch, followed by *C. auratus*(11.5%). The relative proportion of *L. abu*ranged from 10.8% in December to 58.4% in February, and C. *auratus* from 2.7% in March to 30.9% in September. The maximum score of proportion of *L. abu*was 8.2% in December, and for *C. auratus* was 9.1% in March and April (Fig. 2).The relative proportion of sensitive native species fluctuated from 13.1% in September to 72.7% in December, while the proportion of tolerant species ranged from 22.9% in December to 85.5% in September. Three tolerant species (*L. abu*, *C. auratus* and *Alburnusmossulensis*) comprised 53.2% of the total catch. The highest score of proportion of sensitive native species was 72.7% in December, and for tolerant species was 85.5% in September (Fig. 2).

Trophic guilds metrics

The trophic guilds metrics, which is composed of percent of individuals that are considered as herbivorous, carnivorous, omnivorous, detrivorous and piscivorous species, which constituted 47.7, 8.6, 1.3, 32.9 and 8.6% of the total catch, respectively. The highest proportions of them were 84.8%, 28.9%, 4.0%, 58.4% and 18.7%, respectively. *Barbusluteus*was common in the catch and constituted 33.9% of herbivorous species, whereas, *A. mossulensis* consisted 4.9% of carnivorous species, *Cyprinuscarpio*formed 0.7% of omnivorous species, *L. abu* consisted 32.9% of detrivorous species and *Aspiusvorax* 4.8% of piscivorous species. The maximum score of proportion of herbivorous was 10% in December, and of carnivorous and piscivorous were 10% both in November (Fig. 2d). The maximum score of proportions of omnivorous was 9.7% in November, January and September, and of detrivorous was 8.2% in December (Fig. 2d).

Integrated Biological Index (IBI)

The monthly variations in the overall IBI score of fish assemblage in the marsh during the study period is shown in Table 2. The lowest value of IBI was 32.8% in September and the highest value 70.0% in June. The overall IBI value of Huwazah marsh during 2005-2006 was evaluated to be fair (53.2%). In general, the value of IBI was good during October, January and June, fair during November, December, February-May and July-August, and poor during September.

DISCUSSION

Belpaire *et al*. (2000) demonstrated that the IBI concept, which is based on qualifying the integrity of a fish community by evaluating a variety of essential ecological features (species composition, community structure, biological processes (e.g. trophic relationships) and individual health), has a high plasticity and can be used on a variety of aquatic habitats in quite different zoo-geographical regions all over the world.Huwazah marsh is non-tidal freshwater marsh and representing the best remaining natural marsh in the original Mesopotamian wetlands, less harshly degraded of the other southern marshes due to drainage (Richardson and Hussain, 2006). Therefore, the status of study marsh was compared with the adjacent marshes (Table 3), such as Hammar and Chybaish marshes, which suffered from drainage more than Huwazah marsh, during the same period and sampling efforts (Mohamed and Hussain, 2012; Mohamed, 2014) and after four years of inundation (Al-Shamary, 2008). After more than two years of restoration activities and improved water quality, the state of the fish community in Huwazah marsh was fair (IBI= 53.2 %), and was better than Hammar marsh (IBI= 42.6%) and Chybaish marsh (IBI= 45.6%) during the same period and after four years of its restoration, IBI= 37.2-44.5%.

In view of scores for metrics that increase with environmental quality, the proportion of native individuals in Huwazah marsh was higher (84.5%) than that at Hammar marsh, although the restrictionof migratory marine species and high number of native species in Hammar marsh, these fish proportions comprised 70.6% of the total individuals in this marsh, could be due to different environmental setting, since Hammar marsh almost totally desiccated by 2000 (Richardson *et al.,* 2005) and consider as tidal and oligohaline marsh (Hussain and Taher, 2007). Also, large proportions of the herbivores, carnivores and piscivores individuals have made up 65% of the trophic guilds in Huwazah marsh, compared to about 51% for those in Hammar marsh. However, the proportions of aliened individuals, *L. abu* and *C. auratus*, as scores of metrics that increase with decreasing environmental quality were higher in Hammar than at Hawazah marsh. Despite the two marshes had similar species richness values, Huwazah marsh has achieved a more balanced trophic structure (i.e. more piscivores and fewer generalists) over time that is most likely related to water quality and fish habitat improvements (Brousseau and Randall, 2008).

The water quality, water level fluctuation and macrophyte coverage were among the most influential factors affecting fish IBI in wetland ecosystems as reported by several authors (Minns*et al.,* 1994; Brazner and Beals, 1997; Uzarski*et al.,* 2005; Bhagat *et al.,* 2007). In general, the water quality of Huwazah marsh was better than the other restored marshes (Richardson and Hussain, 2006; Adam *et al.,* 2007; Tahir*et al.,* 2008; Hassan *et al.,* 2011), and as expressed by the level of salinity which was dropped as the water flow was continuous through the year, therefore no clear seasonal changes indicated that restoration was continuing to progress during study period. Al-Kenzawi *et al.* (2011) mentioned that the highest level of salinity in Huwazah marsh (Um Alnaaj) was 0.9‰ during summer 2008. Brazner and Beals (1997) stated that increased fish species richness and abundance were often correlated with increased macrophyte species richness and density. According to Al-Abbawy and AI-Mayah (2010), the highest number of aquatic plants species was registered in Huwazah marsh (35) in comparison with Hammar marsh (24),

and the aquatic macrophyte species restoration percentage during 2006 was 97.2% in Huwazah, whereas, 63.2%in Hammar. Also, the density and biomass of the major macrophytes species in Hawazah marsh during July 2006 were 423 g/m² and 21,452 g/m² dry wt., respectively, while for Hammar marsh were 308 g/m² and 11,367 g/m² dry wt., respectively (ARADI, 2006). Currently, restoration by re-flooding of drained marshes is proceeding in the marshes, but the quality and quantity of water depend on the amount of water inflow of the Tigris and Euphrates from Turkey, Syria and Iran. In respect to Huwazah marsh, the amount of water level was decreased during the last years by the dams that established on the water sources on Iran side (Coad, 2010; Al-Kenzawi *et al.,* 2010; Al-Mayah *et al.,* 2012). Odum (1969) reported that specialist species are quickly replaced by opportunists ones when there is environmental alteration. The number of fish species supported by an undisturbed aquatic ecosystem decreases with environmental degradation, as intolerant species will disappear with increasing disturbance (Karr *et al.,* 1986).

Conclusions

The overall study reveals that the fish-based IBI integrated biological index is positively correlated with the species richness, species composition and trophic characteristics of the fish community in the marshes and decreases as the disturbance increase. The index may also present a more accurate assessment of system function than individual measures such as species richness, for example, East-Hammar marsh has more species than at any other marshes, while its overall IBI was low. Moreover, it is found very useful for continuation, permanence, persistence, continuously monitoring of the marshes with respect to the fish community and its integrity with ecosystem.

Acknowledgment

The data on which this paper is based were collected under the Canadian International Development Agency (CIDA)-funded project. Our thanks and gratitude goes to our colleague's team of biologists in the project.

REFERENCES

Abd, I.M. 2010. Ecological assessment of Chybayish marsh using water quality index and index of biological integrity of fish and phytoplankton assemblages. Ph D. thesis.Basrah University, Iraq.

Adam, R.S., Al-Shawi, I.J.M., and Al-Imarah, F.J.M. 2007. Distribution of some chemical elements in the marsh lands of Southern Iraq after rehabilitation. *Marsh Bulletin,* 2: 11-17.

Al-Abbawy, D.A.H. and AI-Mayah, A.A. 2010. Ecological Survey of Aquatic Macrophytes in Restored Marshes of Southern Iraq during 2006 and 2007. *Marsh Bulletin,* 5: 177-196.

Al-Hilli, M.R., Warner, B.G., Asada, T. and Douabul, A. 2009. An assessment of vegetation and environmental controls in the 1970s of the Mesopotamian wetlands of southern Iraq. *Wetlands Ecology and Management,* 17: 207-223.

Al Al-Kenzawi, M.A.H., Al-Haidary, M.J.S. Talib, A.H. and Karomi, M.F. 2011. Environmental study of some water characteristics at Um-Al-Naaj marsh, south of Iraq. *Baghdad Science Journal,* 8: 531-538.

Al-Kenzawi, M.A.H., Asada, T., Hassan, F.M., Warner, B.G., Douabul, A., Al-Hilli, M.R. A., Alwan, A.A. 2010. Vegetation Response to Re-flooding in the Mesopotamian Wetlands, Southern Iraq. *Wetlands,* 30: 377-388.

Al-Khayyat, H. 1957. Geography of the Marshes and Swamps of Southern Iraq. Arab Research and Studies Institute. p.54.

Al-Mayha, A.R.A. 1992. Aquatic plants in marsh of south of Iraq. In: Hussain, N.A.(Ed) Ahwar of Iraq environmental approach. Marine Science Center Publ. (18), 299pp.

Al-Mayah, A.R.A., Al-Abbawy, D.A.H., Al-Assadi, W.M.T., Al-Saadi S.A.A. and Al-Edany, T.Y. 2012. Status of Aquatic Macrophytes in Saffia Nature Reserve, South of Huwaiza Marsh, Iraq. *Marsh Bulletin,* 7: 1-16.

Al-Mowsawi, N.A.A. 2012. Geography of the Marshes. The Southern Mesopotamian Marshlands: Reclaiming the Heritage of a Civilizations. Chapter II. AMAR International Charitable Foundation's Heritage project. London, 2012.

Al- Rubaiy, D.J. 1990. Surface water resources in Basrah Province. *The Arab Gulf,* 22: 145-196.

Al-Saboonchi, A., Mohamed, A.R.M., Alobaidy, A.H.M., Abid, H.S. and Maulood, B. K. 2011. On the current and restoration conditions of the southern Iraqi marshes: Application of the CCME WQI on East Hammar marsh. *Journal of Environmental Protection,* 2: 316-322.

Al-Shamary, A.C. 2008. Ecological assessment for South-East Al-Hammar marsh, north of Basrah.M.Sc. thesis.Basrah University, Iraq.

Anonymous. 2006. Restoration of the Mesopotamian Marsh Lands. A project of nature Iraq. hettp://www. edenagain. org/marsh landinfo. html. 4 May 2006.

ARDI. 2006. Final report, marshlands monitoring team. Development Alternative International. 172pp.

Bhagat, Y., Ciborowski, J.J.H., Johnson, L.B., Uzarski, D.G., Burton, T.M., Timmermans, S.T.A. and Cooper, M.J. 2007. Testing a Fish Index of Biotic Integrity for Responses to Different Stressors in Great Lakes Coastal Wetlands. *Journal of Great Lakes Research,* 33: 224-235.

Belpaire, C., Smolders, R., Auweele, I.V., Ercken, D., Breine, J., Thuyne, G.V. and Ollevier, F. 2000. An Index of Biotic Integrity characterizing fish populations and the ecological quality of Flandrian water bodies**.** *Hydrobiolog,* 434:17-33.

Bozzetti, M. and Schulz, U.H. 2004. An index of biotic integrity based on fish assemblages for subtropical streams in southern Brazil. *Hydrobiologia,*529:133-144.

Brazner, J.C. and Beals, E.W. 1997. Patterns in fish assemblages from coastal wetland and beach habitats in Green Bay, Lake Michigan: a multivariate analysis of abiotic and biotic forcing factors. *Canadian Journal of Fishery and Aquatic Sciences,* 54: 1743-1761.

Brousseau, C.M. and Randall, R.G. 2008. Assessment of long-term trends in the littoral fish community of Hamilton Harbour using an Index of Biotic Integrity. *Canadian Technical Report of Fishery and Aquatic Sciences,* 2811, ii + 85 p.

Coad, B.W. 2010. Freshwater Fishes of Iraq. Pensoft Publishers, Sofia, Bulgaria. 274p + 16 plats.

Evans, M.I. 2002. The ecosystem. In: Nicholson, E., Clark, P. (Ed). The Iraqi Marshlands: A human and environmental study. The Amar appeal international charitable foundation, 299pp.

Hassan, F.M., Al-Kubaisi, A.A., Talib, A.H., Taylor, W.D. and Abdulah, D.S. 2011. Phytoplankton primary production in southern Iraqi marshes after restoration. *Baghdad Science Journal*,8: 519-530.

Hussain, N.A. and Taher, M.A. 2007. Effect of daily Variations, diurnal fluctuations and tidal stage on water parameters of East Hammar marshland, Southern IRAQ. *Marsh Bulletin*, 2: 32-42.

Hussain, N.A., Mohamed, A.R.M., Al-Noor, S.S., Coad, B., Mutlak, F.M., Al-Sudani, I.M., Mojer, A.M., Toman, A.J. and Abdad, M.A. 2006. Species composition, ecological indices, length frequencies and food habits of fish assemblages of the restored southern Iraqi marshes. Annual Report, Basrah University, Iraq. 114p.

Hussain, N.A., Mohamed, A.R.M., Al-Noor, S.S., Mutlak, F.M., Abed, I.M. and Coad, B.W. 2009. Structure and ecological indices of fish assemblages in the recently restored Al-Hammar Marsh, southern Iraq. *BioRisk*, 3: 173–186.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries6: 21-27.

Karr, J.R. and Dudley, D.R. 1981. Ecological perspective on water quality goals. *Environmental Management*, 11: 249-256.

Karr, J.R., Fausch, K.D., Angermeier, P.L., Yant, P.R. and Schlosser, I.J. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Nat. Hist. Surv. Spec. Publ. **5**. 28 pp.

Krause, J., Bertrand, K., Kafle, A., Troelstrup, N. 2012. A Fish Index of Biotic Integrity for South Dakota's Northern Glaciated Plains Ecoregion. 142nd Annual Meeting of the American Fisheries Society, Minneapolis-St Paul, MN, August 19-23, 2012.

Maltby, E. 1994. An environmental and ecological study of the marshlands of Mesopotamia. Draft Consultative Bulletin, Wetland Ecosystems Research Group. University of Exeter. AMAR Appeal Trus, London. pp 224.

Margalef, R. 1968. Perspectives in ecology. University of Chicago Press.111p.

Minns, C.K., Cairns, V.W., Randall, R.G. and Moore, J.E. 1994. An index of biotic integrity (IBI) for fish assemblages in the littoral-zone of Great-Lakes areas of concern. *Canadian Journal of Fishery and Aquatic Sciences*, 51: 1804-1822.

Mohamed, A.R.M. 2014. A Fish Index of Biotic Integrity for evaluation of fish assemblage environment in restored Chybaish marsh, Iraq. Global Journal of Biology, Agriculture & Health Sciences, 3(1): 32-37.

Mohamed, A.R.M. and Hussain, N.A. 2012a. Trophic strains and diet shift of the fish assemblage in the recently restored Al-Hammar marsh, southern Iraq.*Journal of University of Duhok*, 15:119-127.

Mohamed, A.R.M. and Hussain, N.A. 2012b. Evaluation of Fish assemblage environment in east Hammar usg Integrated Biological Index. *Basrah Journal of Science*, 30: 87-105.

Mohamed, A.R.M.,Hussain, N.A., Al-Noor, S.S., Mutlak, F.M., Al-Sudani, I.M., Mojer, A.M. andToman, A.J. 2008.Fish assemblage of restored Al-Hawizeh marsh, Southern Iraq. *Ecohydrology& Hydrobiology*, 8: 375-384.

Mohamed A.R.M., Hussain, N.A., Al-Noor, S.S., Coad, B. and Mutlak, F.M. 2009. Status of diadromous fish species in the restoredEast Hammar marsh in southern Iraq. *American Fisheries Society Symposium*, 69: 577-588.

Mohamed A.R.M., Hussain, N.A., Al-Noor, S.S. and Mutlak, F.M. 2012. 2012. Ecological and biological aspects of fish assemblage in the Chybayish marsh, Southern Iraq. *Ecohydrology& Hydrobiology*, 12: 65-74.

Odum, E.P. 1969. Ecologia. Sao Paulo, Pioneira, 201p.

Partow, H. 2001. The Mesopotamian marshlands: demise of an ecosystem. Early warning and assessment. Division of Early Warning and Assessment, United Nations Environment Programme, Nairobi, Kenya.

Richardson, C. J., Reiss, P., Hussain, N. A., Alwash, A. J, Pool, D. J. 2005. The restoration potential of the Mesopotamian marshes of Iraq. *Science*, 307: 1307-1311.

Richardson, C.J., and Hussain, N.A.. 2006. Restoring the Garden of Eden: An ecological assessment of the marshes of Iraq. *BioScience*, 56: 477-489.

Simon, T.P. 1998. Modification of an index of biotic integrity and development of reference condition expectations of dunal, palustrine wetland fish communities along the southern shore of Lake Michigan. *Aquatic Ecosystem Health and Management*, 1: 49–62.

Simon, T.P., Jankowskib, R. and Morris, C. 2000. Modification of an index of biotic integrity for assessing vernal ponds and small palustrine wetlands using fish, crayfish, and amphibian assemblages along southern Lake Michigan. *Aquatic Ecosystem Health and Management*, 3: 407-418.

Tahir, M.A., Risen, A.K., and Hussain, N.A. 2008. Monthly variations in the physical and chemical properties of the restored southern Iraqi marshes. *Marsh Bulletin*, 3: 81-94.

Uzarski, D.G., Burton, T.M., Cooper, M.J., Ingram, J.W. and Timmermans, S. 2005. Fish habitat use within and across wetland classes in coastal wetlands of the five Great Lakes: development of a fish-based index of biotic integrity. *Journal of Great Lakes Research*, 31: 171-187.

Youns, K.H., Al-Mossawy M.H. and Jabir, A.A. 2011. 2011. Composition structure of fish assemblage in Um Alnaaj, Al-Hawaizah marsh, Iraq. *Basrah Research Journal (Scientific)*,37: 49-59.

****