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[Research]

Assessment of fish farm effluents on macroinvertebrates based on biological indices in Tajan River (north Iran)

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ABSTRACT

Impacts of effluent from fish farming activities on fluvial ecosystems lead to deterioration of water quality and changes in the macroinvertebrates assemblage. In this study, the influence of fish farm effluents on water quality and macroinvertebrates communities of Tajan River was investigated to evaluate the suitability of macroinvertebrates based on biological metrics and indices. Benthic macroinvertebrate communities were analyzed seasonally for a period of one year . Five sampling stations were selected along the study reach of 50 km. Station 1(S1) which is located upstream from the fish farm, was used as the reference site. Station S2 and S3 were located downstream from the fish farm outlet; S4 and S5 were further downstream. In order to assess the changes in diversity and richness in relation to water quality, two major groups of sites based on similarity between macroinvertebrate communities identified by cluster analysis. Diversity of macroinvertebrates, EPT richness and EPT/CHIR indices significantly decreased toward downstream stations except for station S4. Conversely, values of HFBI and Jacard index significantly increased in the downstream stations. The present study revealed significant differences in water quality parameters between the stations located above and below the fish farms. Owing to the relatively high diversity of benthic macroinvertebrates inhabiting rivers, use of macroinvertebrate based biological indices is recommended for assessment of water quality and pollution in fluvial systems.

Keywords: *Benthic macroinvertebrates, Diversity indices, Fish farm, Pollution.*

INTRODUCTION

Fish farm pollutants come mainly from uneaten food, fecal matter, and soluble metabolites (Kendra, 1991). Despite the fact that the aquaculture industry has proven to be a reliable source of fish over the years, its growth has been commensurate with the deterioration of pond effluent-receiving waters. In recent years the negative impacts of fish farming on natural ecosystems have come under severe public criticism (e.g., Goldburg & Triplett, 1997; Naylor *et al.*, 2000), which leads to deterioration of water quality and changes of the stream bottom structure. Only a small percentage of ingested feed is retained as fish biomass, with the rest lost to the pond environment as fecal solids, uneaten feed and dissolved nutrients (Boyd & Tucker, 1998; Tucker & Hargreaves, 2003). Increase in concentration of organic matter, nutrients, and suspended solids in culture ponds leads to an increase in oxygen demand, eutrophication and turbidity in receiving waters (Beasley & Allen, 1974; Shireman & Cichra, 1994; Naylor *et al*., 2000; Lin & Yi, 2003).

Pollution of water resources by fish farm effluents is probably the most common complaint, and this concern has attracted the greatest amount of official attention in most nations (Boyd, 2003). Biological pollution, which is the introduction of unwanted non-native species to natural ecosystems from aquaculture facilities, can harm ecosystems by altering species composition or by reducing biodiversity (Courtenay & Williams, 1992; Mottram, 1996; Goldburg & Triplett, 1997). These species may feed on native species, compete with native species for food and for space, modify or destroy habitat of native species, and introduce new diseases and parasites (Krueger & May, 1991). A number of aquatic organisms have been proposed and used in assessing water quality, but macroinvertebrates (Hellawell, 1986) are one of the most recommended and utilized biological indicators. The advantages to using either of these organisms have made them popular (Rosenberg & Resh, 1993). Macroinvertebrates are ubiquitous in river systems and in the different habitats of each of these systems, and so they are exposed to the various environmental perturbations at these locations (Lenat et al., 1980; Scardi *et al.*, 2006). These organisms are also relatively easy to collect and identify (Depaw *et al.*, 2006; Scardi *et al.*, 2006), and several methods of data analysis have been developed for fish and macroinvertebrate biomonitoring (e.g., Hilsenhoff, 1977; Karr, 1981; Resh & Jackson, 1993).

Macroinvertebrates have known to be distributed non-randomly, and so a large number of samples are needed to achieve the required precision (Hellawell, 1986; Abel, 1989; Depaw et al, 2006). In addition, the distribution of macroinvertebrates influenced by other factors besides water quality, such as current velocity, nature of substrate and the seasonality of life cycles (Suess, 1982; Tachet et al., 2002). These factors could result in the establishment of different macroinvertebrate communities at different sites with identical water quality (Giller & Malmqvist, 1998). These limitations notwithstanding the advantages of using macroinvertebrates, far outweigh the disadvantages (Scardi et al., 2006), and there are recommended ways to deal with these challenges (e.g. Rosenberg & Resh, 1993).

It is obvious that water chemistry alone is inadequate in determining the effects of fish farm effluents on the quality of receiving waters. Water chemistry is altered only for a short period after the release of effluents into a lotic ecosystem, but the very existence of aquatic living systems integrates everything that has happened where they live, as well as what has happened upstream and upland (Karr & Chu, 1999).

Receiving streams of aquaculture effluent dilute a wide range of pollutants, such as nutrients and suspended solids, but few studies on streams below fish farms document effects in the biotic community. Biomonitoring is particularly useful in developing countries (e.g. Iran) as it frequently involves low cost and has low technical requirements. The potential impact of fish farm effluents on water resources is not well studied in Iran. Therefore, procedures for regulating, controlling, and monitoring the environmental impact of fish farms are not well established. The lack of site-specific data on the effluent quality of farms and on their impact on receiving streams and rivers is a major constraint on the establishment of such regulatory measures and adaptation of appropriate waste management systems. Hence, this study aims to determine the effects of fish farm effluents on the structure and function of receiving river macroinvertebrates communities, as a proxy to the impacts of these effluents on receiving river water quality. The specific objectives were to:

1. Examine community condition metrics between receiving and reference station
2. Assess the relationships between water quality and biotic condition of stream

MATERIALS AND METHODS

Study area

Tajan river basin (2000 km2) is a predominantly calcareous basin from northern Iran, which drains into the Caspian Sea. The geographic location of the area lies between 36°09′17″–36°29′49″N lat. and 53°04′57″–53°18′26″E long. The average annual temperature is approximately 15 degrees Celsius (Masoudiyan *et al.*, 2010). During the period of study, the water temperature fluctuated between 11 ◦C and 23 ◦C in relation to the season. The region is drained by the rivers Sefid rud, Shirin rud, Garm rud and Zaram rud. Five sampling stations were selected along the study reach: station 1 placed upstream from the trout farm was used as a reference station; S2 and S3 were placed downstream from the trout farm effluent. S4 was situated below the tributaries of Sefid rud, Garm rud and Zaram rud, and S5 placed downstream from Tajan River (Fig. 1). The sampling stations (S1-S5) were distributed along 50 Km of the river reach. The stream bottom was mainly stony with cobbles and pebbles at all sampling sites.

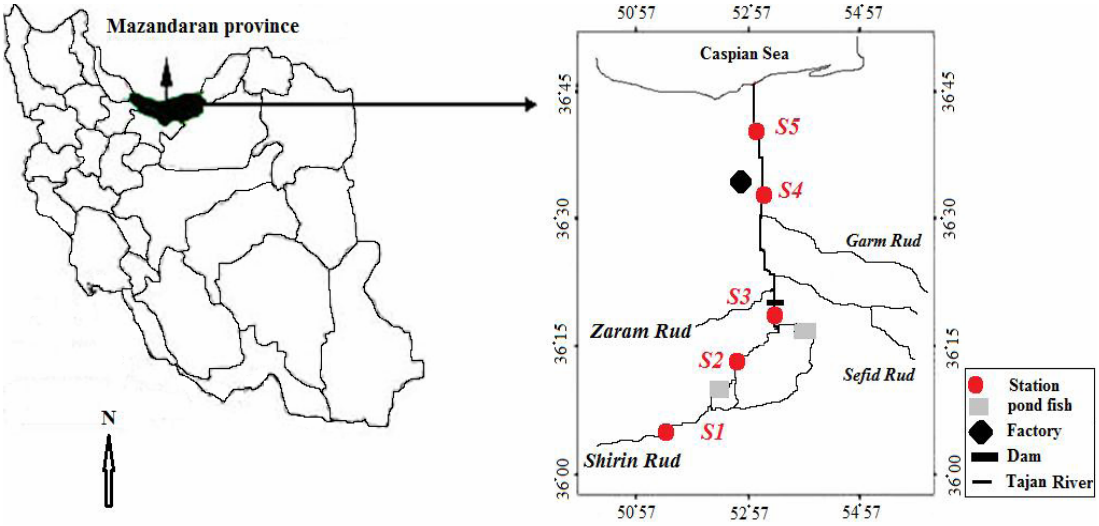

Fig 1. Location of study area and sampling stations (S1–S5) (direction of river flow is south to north).

Field sampling and sample analysis

Qualitative samplings of macroinvertebrates were performed seasonally, completing one year round (2010–2011) in each sampling site. Macroinvertebrates were collected using a Surber's sampler (40cm × 40cm aperture, 100-mm-mesh size) by kicking and sweeping in all microhabitats present at the site in accordance with the CEN standard (UNE-EN 27828, 1994). The Surber's sampler contents were checked and deposited periodically in plastic jars to avoid losing organisms by overflow from the nets. The samples were fixed in 4% buffered formaldehyde for later identification in the laboratory. Additional information on associated hydrochemical parameters can be found elsewhere (Oscoz *et al*., 2005). Macroinvertebrates were identified complete to taxonomic family and genus. Identifications were based on recognized keys, including Pescador et al., 2004; Pennak, 1953; Edmonson 1959; Needham, 1976; Quigley, 1986; Tachet *et al.*, 2000.

Physicochemical measurements were made for each stream. Dissolved oxygen, pH, temperature and conductivity were measured in situ by field meters Multiline P4 and turbidity measured by turbidity meter TB-100. TDS were measured using TDS meter and TSS using vacuum pump and cellulose acetate filters, with a pore size of 0.45 micrometer up to the nearest 0.001 g (Hughes, 1978).

We calculated Family richness and abundance of Ephemeroptera, Tricoptera, Plecoptera (EPT) and Chironomidae taxa metrics. EPT are recognized as orders that are sensitive to pollution (Lenat, 1988), while Chironomidae are tolerant to pollution. The commonly used non-parametric community structure indices including Jacard index (J), Margalef's index (R), Shannon –Wiener diversity index (H) and Simpson's diversity index (D) were calculated, based mostly on the genus (Washington, 1984). The HFBI combines the pollution tolerance scores and the relative abundance of taxa in to determine the level of organic pollution at a site (Zimmerman, 1993). The HFBI is calculated as:

$$HFBI = \frac{\sum (x_i t_i)}{n}$$

Statistical analyses

All statistical analyses were conducted using the SPSS 16.0 software. Mean values of physicochemical parameters were compared between sampling stations (S1, S2, S3, S4 and S5) by means of one way analysis of variance (ANOVA). A mixed-effects ANOVA with farm as random blocks and fixed location effects was the main model, using the Tukey procedure for post-hoc analyses of location effects. The degree of similarity between macroinvertebrate communities and the classification of sites was conducted by PC-ORD 4.17 software and defined basis of Ward's method and a hierarchical cluster analysis (Bis *et al*., 2000).

RESULTS

Macroinvertebrate assemblages

The examination of samples resulted in a total number of 28 families representing 26 genus and 13 orders of benthic macroinvertebrates (Table 1). The total number of identified families varied between 7 and 14 among the sites. The lowest numbers of families were 5 at sampling sites S3 and S5. The Plecoptera, Ephemeroptera and Trichoptera orders were absent at two stations (S3 and S5).

Table 1. Taxonomical list of benthic macroinvertebrates which were determined in Tajan River

Order	Family	Genus
Tricladida	Planariidae	*Phagocata* sp.
Tubificida	Naididae	-
Haplotaxida	Haplotaxidae	-
Lumbricida	Lumbricidae	-
Rhynchobdellida	Glossophonidae	*Glossiphonia* sp.
Basommatophora	Physidae	*Physa* sp.
Prosobranchiata	Valvatidae	*Valvata* sp.
	Hydrobiidae	*Bithynia* sp.
		Potamopyrgus sp.
	Sphaeriidae	*Pisidium* sp.
Ephemeroptera	Baetidae	*Baetis* sp.
		Cloeon sp.
	Heptageniidae	*Epeorus* sp.
	Ephemerellidae	*Ephemerella* sp.
	Leptophlebiidae	*Leptophlabia* sp.
	Caenidae	*Caenis* sp.
Hemiptera	Hydrometridae	*Hydrometra* sp.
Plecoptera	Chloroperlidae	*Chloroperla* sp.
	Perlidae	*Perla* sp.
Coleoptera	Elmidae	-
Trichoptera	Hydropsychidae	*Hydropsyche* sp.
	Rhyacophilidae	*Rhyacophila* sp.
	Glossosomatidae	*Agapetus* sp.
	Hydroptilidae	*Hydroptila* sp.
Diptera	Tipulidae	*Tipula* sp.
	Blephariceridae	*Liponeura* sp.
	Ceratopogonidae	*Bezzia* sp.
	Simuliidae	*Simulium* sp.
	Tabanidae	*Tabanus* sp.
	Chironomidae	*Shironomus* sp.

Overall, the benthic macroinvertebrate communities of Tajan River were dominated by *Chironomus* larvae (39%). The second dominant taxa were Baetis (22%). Five families including Chironomidae, Simuliidae, Tubificidae, Naididae and Lumbricidae were recorded at all sampling stations.

According to Wards similarity index, the highest similarity was observed between the stations 3 and 5. Stations 1 and 4 showed the highest differences in benthic macroinvertebrates in terms of number and taxa. The site classification based on the macroinvertebrate composition using cluster analysis is presented in Figure 2. The dendrogram separates all sampling sites into two major groups. The first group consists of the S1 and S4 stations whereas the second group contains S2, S3 and S5 stations. The results of the cluster analysis allowed for further separation of tow sub groups of sites in the second major group.

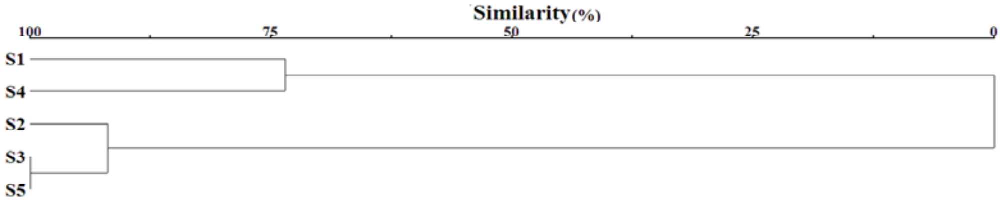

Fig 2. The dendrogram of similarity of stations (S1– S5) in Tajan River based on benthic macroinvertebrates data

Biological indices and physicochemical parameters

A summary of the calculated biotic and community structure indices and physico-chemical characteristics of the sampling sites are presented in Table 2. The different levels of water quality variables indicate that water pollution are significantly apparent from upstream to downstream stations.

The highest EPT richness and EPT/CHIR indices were observed in station S1 and S4 which showed significant differences with other stations ($P<0.05$), while the lowest indices were calculated in S3 and further downstream in station (S5).

According to the results of HFBI at each station (Table 2), Tajan River is comprised of three water quality classes (Hilsenhoff, 1988). Based on the results, stations (S1 and S4) were categorized as ''good''; S2 and S3 in the ''moderately polluted'' and the downstream station (S5) in the ''fairly polluted''. Whereas, according to the Shannon–Wiener diversity index (Wilhm & Dorris, 1968), the S1 station were categorized as ''good'', stations S2 and S3 ''moderate'' and S5 moderate to substantially polluted classes (Table 2). The other biological indices i. e. Margalef and Simpson followed the same trend and indicated an overall increase in nutrient pollution, particularly along the downstream part of the river.

All water physicochemical parameters, except pH, were significantly different among the sites (Table 2). The highest oxygen concentrations were observed upstream (S1 to S4). The lowest oxygen concentrations were recorded in the downstream station (S5), which was significantly different from other stations ($P<0.05$). The EC, Turbidity, TSS and TDS, gradually increased from upstream to downstream.

Table 2. Mean values (±SD) of environmental and physicochemical parameters, biotic indices, richness and diversity indices at the sampling sites of Tajan River

Parameters \ sites	S1	S2	S3	S4	S5
Margalef's index (R)	1.64 ± 0.29^{a}	0.96 ± 0.20^{b}	0.82 ± 0.31^{b}	1.17 ± 0.08^{ab}	0.68 ± 0.11^{b}
Shannon-wiener diversity (H)	1.86 ± 0.10^{a}	1.57 ± 0.12^{ab}	1.39 ± 0.28^{b}	1.65 ± 0.13^{ab}	1.35 ± 0.07^{b}
Jacard index (J)	0.38 ± 0.08^{b}	0.58 ± 0.08^{a}	0.65 ± 0.13^{a}	0.51 ± 0.02^{ab}	0.68 ± 0.03^{a}
Simpson's diversity index (D)	0.80 ± 0.02^{a}	0.74 ± 0.04^{ab}	0.67 ± 0.13^{b}	0.76 ± 0.03^{ab}	0.67 ± 0.03^{b}
HFBI	4.30 ± 0.30^{b}	5.08 ± 0.50^{ab}	5.06 ± 0.59^{ab}	4.34 ± 0.44^{b}	5.57 ± 0.39^{a}
EPT richness	8.25 ± 1.26^{a}	3.75 ± 1.5^{b}	3.25 ± 0.5^{b}	5 ± 1.41^{a}	2.75 ± 0.5^{b}
EPT/CHIR	2.32 ± 0.92^{a}	1.15 ± 0.38^{b}	1.17 ± 0.9^{b}	3.22 ± 1.66^{a}	0.82 ± 0.39^{b}
DO (mg l^{-1})	9.83 ± 0.43^{a}	8.78 ± 0.42^{ab}	8.45 ± 0.68^{ab}	8.93 ± 0.65^{ab}	6.78 ± 0.48^{b}
pH	7.53 ± 0.13	7.78 ± 0.10	7.93 ± 0.48	7.63 ± 0.13	7.88 ± 0.25
EC (µs cm^{-1})	555 ± 36.97^{b}	635 ± 36.97^{b}	815 ± 170.5^{b}	865 ± 79.3^{b}	1560 ± 573.4^{a}
Turbidity (mg l^{-1})	30 ± 4.08^{c}	42 ± 6.68^{bc}	52.50 ± 11.15^{b}	46.75 ± 4.27^{b}	77 ± 9.76^{a}
TSS (mg l^{-1})	88 ± 16.51^{b}	140.25 ± 20.50^{ab}	177.5 ± 50.77^{a}	168.2 ± 14.06^{a}	177.2 ± 27.8^{a}
TDS (mg l^{-1})	316.2 ± 70.4^{c}	423.7 ± 17.9^{c}	790 ± 110.4^{b}	717.5 ± 97.4^{b}	982.5 ± 148.6^{a}
Water temperature (^{o}C)	12 ± 1.41^{b}	13.25 ± 1.26^{ab}	15.5 ± 2.38^{ab}	15.88 ± 3.42^{ab}	16.75 ± 4.19^{a}
Water flow (m s^{-1})	0.2 ± 0.08^{b}	0.2 ± 0.08^{b}	2.03 ± 3.32^{b}	14.5 ± 8.19^{a}	14.5 ± 8.19^{a}

Values with different letters indicate significant mean differences following Tukey post hoc tests ($p<0.05$).

An examination of the correlation of DO, pH, EC, salinity, turbidity, TSS, TDS, temperature and water flow with macroinvertebrate metrics revealed trends in most of these metrics associated with levels of these three physicochemical variables (Table 3). pH were negatively correlated to R, H, D and EPT richness metrics except HFBI and Jacard index, while had not correlation with EPT/CHIR index. DO showed strong correlation with HFBI Index and also TSS showed significantly negative correlation with EPT richness, while there was no significant difference between the other parameters and macroinvertebrate metrics.

Table 3. Pearson correlation coefficients of biological indices and water physicochemical variables

Index/Parameter	DO (mg l^{-1})	pH	EC (µs cm^{-1})	Turbidity (mg l^{-1})	TSS (mg l^{-1})	TDS (mg l^{-1})	Temperature (^{o}C)
Margalef's index (R)	.87	-.94*	-.68	-.84	-.88*	-.79	-.76
Shannon-wiener index (H)	.87	-.96**	-.70	-.86	-.87	-.84	-.78
Jacard index (J)	-.87	.96**	.69	.85	.86	.80	.75
Simpson's diversity index (D)	.83	-.97**	-.67	-.82	-.81	-.81	-.73
HFBI	-.88*	.87*	.70	.81	.58	.62	.51
EPT richness	.78	-.91*	-.57	-.76	-.89*	-.73	-.73
EPT/CHIR	.63	-.80	-.40	-.54	-.28	-.31	-.16

DISCUSSION

Bentic macroinvertebrates

The obtained results suggest that the effects of fish farming on the benthic macroinvertebrates are noticeably below the farm (S2 and S3) and downstream station (S5). The numbers of Ephemeroptera taxa were highest in two stations (S1 and S4), while they were absent in two other stations (S3 and S5). Station 4 is located below the conjunction of three streams entering Tajan River and this may improve water quality and therefore number of Ephemeroptera as an indication of increase in water pollution from upstream towards downstream and specially below the fish farm which has also been mentioned by Camargo (1992 & 1994) and Crawford et al (2001& 2002). Chironomidae family was dominant taxa at three stations (S2, S3 and S5). The downstream effects of the fish farm effluent on macroinvertebrates vary in distance and magnitude from site to site. The usual observations are an increase in pollution-tolerant taxa directly after the outfall, while a decrease in pollution-sensitive taxa and also total species richness and a shift in dominant functional feeding groups (Kendra, 1991). The Baetidae family was the main dominant taxa followed by Chironomidae at S1 and S4. At S5, Chironomidae, Lumbricidae and Simuliidae families were the dominant taxa, which are known to be able to tolerate unfavourable conditions such as low dissolved oxygen and high pollution level (Camargo, 1992, 1994).

Cluster analysis of the macroinvertebrates abundance data showed that the studied sites split into two main groups (Fig. 2) and the resulted groupings largely reflect the pollution status in stations 2, 3 and 5 and less polluted or unpolluted stations 1 and 4. Our results are similar to those obtained by Zivic *et al* (2009) and Camargo *et al* (2011) who investigated the effects of fish farm on macroinvertebrates assemblages.

Biological indices and physicochemical parameters

The highest values of EPT taxa richness and EPT/CHIR indices were observed in stations 1 and 4 and it was significantly differed from that recorded in other stations ($P<0.05$), while the lowest values were observed in S3 (below the fish farm) and downstream station (S5). Effluent from fish farms reduces the abundance of sensitive-taxa and increases the numbers of tolerant-taxa (Doughty & McPhail 1995), however in the present study, increase in taxa abundance in station S4 was mainly due to receiving water from Sefid Rud, Garm Rud and Zaram Rud tributaries.

Many studies have used HFBI index for classification of water pollution (Lenat, 1993; Entrekin *et al*., 1993; Lydy *et al*., 2000; Volker & Rann, 2000). In this study, the sampling stations were divided into three categories based on HFBI index as ''good quality'' (S1 and S4); ''moderate polluted'' (S2 and S3) and ''fairly polluted'' (S5) (Hilsenhoff, 1977). The wastewater influx from the trout farm also led to significant changes in the HFBI index of macroinvertebrate communities of Tajan River (Table 2). Stations 2 and 3, showed good water quality only in rainy spring season, while in the rest of the year water quality declined to moderate mostly due to receiving effluent of the fish farm (as mentioned by Kamali *et al*., 2009; Ghanesasansarai, 2004).

Values of dissolved oxygen, turbidity, TSS and TDS clearly indicated that effluents from the trout farm polluted S2 and S3 (Table 2). Increase in temperature, suspended solids (i.e., turbidity) and organic and inorganic solids, and decrease in dissolved oxygen and settlement of suspended solids on the river bottom are the physicochemical changes often observed in rivers and streams receiving fish farm effluents (Axler *et al*., 1997; Jones, 1990; Selong and Helfrich, 1998; Bartoli *et al*., 2007; Simões *et al*., 2008; Ruiz-Zarzuela *et al.,* 2009). In the present study, these physicochemical alterations were more evident below the fish farm (S2 and S3) and downstream station (S5) with a clear tendency to reduce with increasing downstream distance from the fish farm effluent (Table 2). The wastewater treatment system of the fish farm was clearly insufficient to prevent marked physicochemical changes in the recipient stream and, consequently, this fish farm should significantly improve its wastewater treatment system in order to lessen the harmful impacts of the ecological characteristics of Tajan River. The conductivity gradually increased from upstream towards downstream which is similar to the findings of Boaventura *et al*. (1997). Fish farm effluents did not have a significant impact on the pH of Tajan River. The minor elevation in pH was not statistically significant. Even the pH in downstream of the fish farms was still 6.5–9.5 as proposed acceptable by different standard schemes (Lawson, 1995; Davis, 1993; Boyd & Gautier, 2000).

There was a reduction in the DO concentration of Tajan River as a result of fish farming activities. The DO concentration of Tajan River was low below the fish farms throughout the study period. The lowest value of DO (6.78± 0.48 mg/L) was observed in S5 and downstream stations of the fish farm (S2 and S3). This value was above the minimum limits of 6.0 and 6.6 mg/L suggested for DO (mg/L) content of receiving waters in similar studies (Davis, 1993; Midlen & Redding, 1998; Lawson, 1995). Furthermore; the lowest value of DO observed in Tajan River still exceeded the upper limit of DO concentration (5 mg/L or more for DO) that is recommended by the Global Aquaculture Alliance (Boyd & Gautier, 2000).

Changes in the value of metrics and indices based on the macroinvertebrate community (Table 2) reflect a substitution of sensitive macroinvertebrates for tolerant ones. For example, sensitive Ephemeroptera, Plecoptera and Trichoptera decreased in abundance, whereas the abundance of tolerant Tubificidae worms, dipterans (mainly Chironomidae), and molluscs increased. Reductions in dissolved oxygen concentrations and increases in EC, TSS, TDS and turbidity would be responsible, in part, for these changes in the abundance of benthic macroinvertebrates downstream of the fish farm. Tubificidae and Chironomidae have been found to be characteristic macroinvertebrates in that type of water (Hellawell, 1986; Camargo, 1992, 1994; Loch *et al*., 1996; Selong & Helfrich, 1998; Roberts *et al*., 2009).

None of the correlation coefficients between physicochemical parameters of water and macroinvertebrates metrics and indices were not significant (Table 2). The performance of metrics and indices based on benthic macroinvertebrates to assess the fish farm pollution was relatively good, mainly due to the behaviour of R, H and D metrics and EPT taxa richness, EPT/CHIR and HFBI indices. Actually, HFBI had higher values at downstream polluted stations (S2, S3 and S5) than at the reference station (S1), whereas EPT richness, EPT/CHIR and community indices (R, H and D) had lower values at S2, S3 and S5 than at S1 and S4 (Table 2). Besides, macroinvertebrate metrics and indices (R, H and D metrics and EPT taxa richness and HFBI) had significant correlation ($P < 0.05$) with water physicochemical parameters (dissolved oxygen, pH and TSS) (Table 3). The satisfactory performance of macroinvertebrate metrics and indices (R, H and D metrics and EPT taxa richness and HFBI) to assess freshwater pollution in this case study agrees, in general, with the findings of other polluted sites (Washington, 1984; Hellawell, 1986; Rosenberg & Resh, 1993; Camargo, 1994; Camargo *et al*., 2004; Zivic *et al*., 2009).

CONCLUSION

This study indicated that fish farm effluents cause a significant impact on the water quality of Tajan River with respect to dissolved oxygen (DO), turbidity, total suspended solid (TSS), total dissolved solid (TDS) and electrical conductivity (EC) values. The biological alterations downstream from fish farm effluents can greatly depend on the particular ecological characteristics of each recipient river. further studies are needed in order to generalize this conclusion. The presence of certain benthic macroinvertebrate taxa particularly in polluted and non-polluted parts of a river indicate that they could be used as potential bioindicators in river assessment. The life history of the benthic macroinvertebrates has poorly been studied in Iran. However, the methods used on identified benthic macroinvertebrates in Tajan River proved its applicability for future studies in other regions of the country.

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ارزیابی اثرات زه آب مزرعه پرورش ماهی روی شاخص های بیولوژیک بر پایه بی مهرگان بزرگ در رودخانه تجن

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خلاصه:

اثرات زه آب ناشی از فعالیت های پرورش ماهی بر روی اکوسیستم های رودخانه ای منجر به تخریب کیفیت آب این اکوسیستم ها و تغییر در اجتماع بی مهرگان آن می شود. در بررسی حاضر تاثیر زه آب مزرعه پرورش ماهی روی کیفیت آب و نیز جوامع بی مهرگان بزرگ رودخانه تجن بررسی شد تا مناسب بودن شاخص هایی که بر اساس استفاده از بی مهرگان استوار هستند مورد ارزیابی قرار گیرد. جوامع موجودات بنتیک به صورت فصلی به مدت یک سال مورد مطالعه قرار گرفتند. تعداد ۵ ایستگاه نمونه برداری در طول مسیری از رودخانه به طول ۵۰ کیلومتر انتخاب شدند. ایستگاه اول (S_1) در بالادست مزرعه پرورش ماهی و به عنوان ایستگاه مرجع انتخاب شد. ایستگاه های S2 و S3 در پایین دست و در فاصله ای نزدیک به مزرعه و ایستگاه های S4 و S5 در فاصله دورتری از آن تعیین شدند. برای ارزیابی تغییر در تنوع و غنای جوامع بی مهرگان و ارتباط آن با کیفیت آب از آنالیز خوشه ای استفاده شد و ایستگاه ها بر اساس شباهت های موجود بین جوامع بی مهرگان در دو گروه مشخص قرار گرفتند. تنوع بی مهرگان بزرگ، غنای EPT و نسبت EPT/CHIR بطور معنی داری به سمت پایین دست رودخانه (به جز S4) کاهش پیدا کرد اما مقادیر HFBI و شاخص شباهت Jaccard افزایش چشمگیری به سمت پایین دست رودخانه نشان دادند. مطالعه حاضر تغییرات بارز در پارامترهای کیفیت آب در ایستگاه های بالا و پایین مزرعه پرورش ماهی را آشکار کرد. با در نظر گرفتن تنوع بالای جوامع بی مهرگان ساکن در رودخانه ها استفاده از شاخص های بیولوژیک با بکارگیری این موجودات برای ارزیابی کیفیت آب و نیز آلودگی سیستم های آب جاری پیشنهاد می شود.

* نویسنده مسئول