TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

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The Wetlands Diversity

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

Sibiu - Romania
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Faculty of Sciences,
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Published based mainly on some of the scientific materials presented
at the 41st International Association for Danube Research Conference
"Tributaries as Key Elements in Sustainable Management of the Danube River Basin" -
Sibiu/Romania 13-16 September 2016

ESENIAS East and South European network for Invasive Alien Species	Ecotur Sibiu N.G.O.	"*Lucian Blaga*" University of Sibiu	International Association for Danube Research

Sibiu - Romania
2017

IN MEMORIAM

Dan Munteanu
(1937 – 2017)

The Romanian biologist *Dan Munteanu* was born in Cluj, in Transylvania, on the 2nd of June 1937.

After graduating from the Natural Sciences Faculty at Babeş-Bolyai University of Cluj, in 1969 he obtained his Doctorate in Biology at the University of Bucharest by defending his doctoral thesis on the Bird fauna of the Mountain Areas of the Moldavian Bistrița River.

A complex personality, *Dan Munteanu* was known in scientific circles as one of the most competent and active ornithologists of Romania, with a solid and wide-ranging background in classical biology.

He chaired the Romanian Ornithological Society; he was member of the Executive Board of the International Waterfowl and Wetlands Research Bureau of Slimbridge (UK); and was representative of the International Council for Bird Preservation of Cambridge (UK). In this last quality he took part in a variety of European nature conservation and preservation programmes.

His bird fauna studies represent a comprehensive list of works, not only in terms of numbers but also of quality, the most important being the following: Provisional Atlas of Romanian breeding birds, a work carried out for the international committee responsible of the European Atlas; the Birds Chapter in the Romanian Red Book of Vertebrates, in the Editions of the Romanian Academy, 2005; Romanian Bird Areas – Documentations, ALMA MATER Editions, Cluj-Napoca, 2004; Rare, vulnerable and endangered birds in Romania, ALMA MATER Editions, Cluj-Napoca, 2009; Romanian Fauna, Aves, Volume XV, Fascicule 2, Editions of the Romanian Academy. 2015.

Dan Munteanu, as a member of the Romanian Academy, was also very effective in advising on broader environmental issues faced by Romania.

Starting with 2000, he chaired the Commission for the Protection of Nature Monuments of Romania, and solved very competently all problems related to its organisation and functioning. In the same quality, he coordinated the activity of the Scientific Councils of Nature Parks and National Parks. He contributed substantially to the establishment of new protected areas and proposed viable solutions for the conservation of biodiversity and the protection of natural heritage.

The death of *Dan Munteanu*, after a long and painful illness, is a great loss for Romanian biology in the many important areas to which he dedicated his tireless lifelong activity.

A generous and modest man, who dedicated his life to the protection of nature, has left us and will be greatly missed.

The Editors

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Preface

In a global environment in which the climate changes are observed from few decades no more only through scientific studies but also through day by day life experiences of average people which feel and understand allready the presence of the medium and long-term significant change in the “average weather” all over the world, the most comon key words which reflect the general concern are: heating, desertification, rationalisation and surviwing.

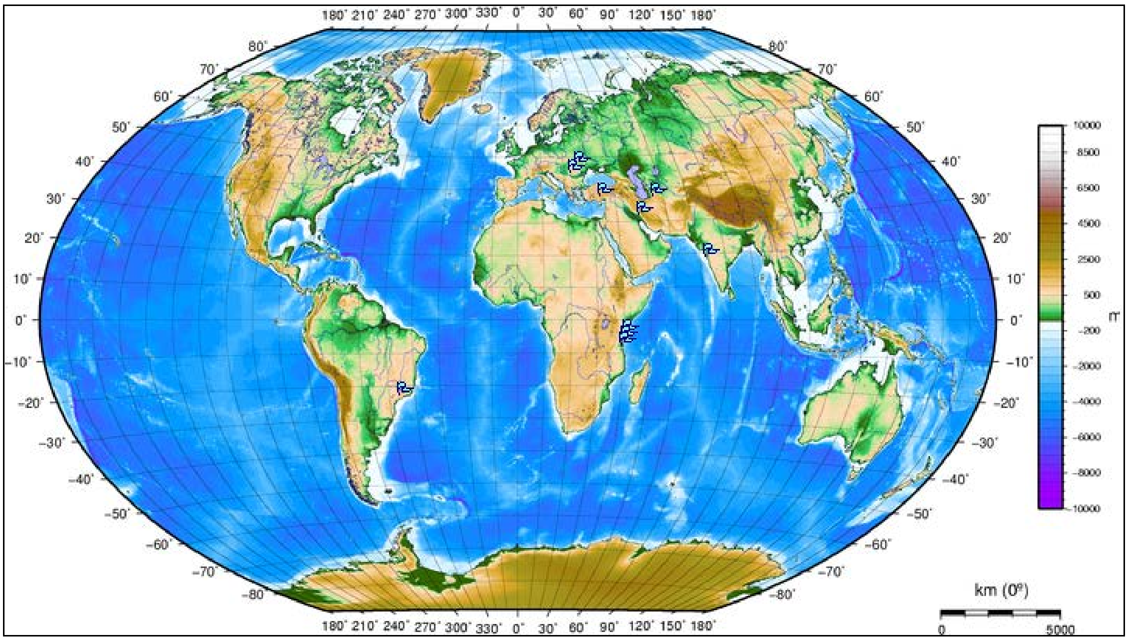
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

With the fact in mind that these aproaces and efforts shuld be based on genuine scientific understanding, the editors of the *Transylvanian Review of Systematical and Ecological Research* series launch three annual volumes dedicated to the wetlands, volumes resulted mainly as a results of the *Aquatic Biodiversity International Conference*, Sibiu/Romania, 2007-2017.

The therm wetland is used here in the acceptance of the Convention on Wetlands, signed in Ramsar, in 1971, for the conservation and wise use of wetlands and their resources. **Marine/Coastal Wetlands -** Permanent shallow marine waters in most cases less than six metres deep at low tide, includes sea bays and straits; Marine subtidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows; Coral reefs; Rocky marine shores, includes rocky offshore islands, sea cliffs; Sand, shingle or pebble shores, includes sand bars, spits and sandy islets, includes dune systems and humid dune slacks; Estuarine waters, permanent water of estuaries and estuarine systems of deltas; Intertidal mud, sand or salt flats; Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, includes tidal brackish and freshwater marshes; Intertidal forested wetlands, includes mangrove swamps, nipah swamps and tidal freshwater swamp forests; Coastal brackish/saline lagoons, brackish to saline lagoons with at least one relatively narrow connection to the sea; Coastal freshwater lagoons, includes freshwater delta lagoons; Karst and other subterranean hydrological systems, marine/coastal. **Inland Wetlands -** Permanent inland deltas; Permanent rivers/streams/creeks, includes waterfalls; Seasonal/intermittent/irregular rivers/streams/creeks; Permanent freshwater lakes (over eight ha), includes large oxbow lakes; Seasonal/intermittent freshwater lakes (over eight ha), includes floodplain lakes; Permanent saline/brackish/alkaline lakes; Seasonal/intermittent saline/brackish/alkaline lakes and flats; Permanent saline/brackish/alkaline marshes/pools; Seasonal/intermittent saline/brackish/alkaline marshes/pools; Permanent freshwater marshes/pools, ponds (below eight ha), marshes and swamps on inorganic soils, with emergent vegetation water-logged for at least most of the growing season; Seasonal/intermittent freshwater marshes/pools on inorganic soils, includes sloughs, potholes, seasonally flooded meadows, sedge marshes; Non-forested peatlands, includes shrub or open bogs, swamps, fens; Alpine wetlands, includes alpine meadows, temporary waters from snowmelt; Tundra wetlands, includes tundra pools, temporary waters from snowmelt; Shrub-dominated wetlands, shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils; Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils; Forested peatlands; peatswamp forests; Freshwater springs, oases; Geothermal wetlands; Karst and other subterranean hydrological systems, inland. **Human-made wetlands -** Aquaculture (e. g., fish/shrimp) ponds; Ponds; includes farm ponds, stock ponds, small tanks; (generally below eight ha); Irrigated land, includes irrigation channels and rice fields; Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture); Salt exploitation sites, salt pans, salines, etc.; Water storage areas, reservoirs/barrages/dams/impoundments (generally over eight ha); Excavations; gravel/brick/clay pits; borrow pits, mining pools; Wastewater treatment areas, sewage farms, settling ponds, oxidation basins, etc.; Canals and drainage channels, ditches; Karst and other subterranean hydrological systems, human-made.

The editors of the *Transylvanian Review of Systematical and Ecological Research* started and continue the annual sub-series (*Wetlands Diversity*) as an international scientific debate platform for the wetlands conservation, and not to take in the last moment, some last heavenly "images" of a perishing world …

This 15th volume included variated researches from diverse wetlands around the world.



The subject areas ( ) for the published studies in this volume.

No doubt that this new data will develop knowledge and understanding of the ecological status of the wetlands and will continue to evolve.

Acknowledgements

The editors would like to express their sincere gratitude to the authors and the scientific reviewers whose work made the appearance of this volume possible.

The Editors

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(ISSN-L 1841 – 7051; online ISSN 2344 – 3219)

THE DETERMINATION OF SOME POLLUTION PARAMETERS, WATER QUALITY AND HEAVY METAL CONCENTRATIONS OF ACI LAKE (KARAPINAR/KONYA, TURKEY)

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DOI: 10.1515/trser-2017-0001

KEYWORDS: Water quality, Heavy metals, pollution, Acı Lake.

ABSTRACT

Water quality parameters were measured in Acı Lake. The measurements were carried out in water samples taken from five different stations over ten months. According to the results of the analyses done on the samples of water, without taking into consideration the differences of seasons and stations, the average annual values of heavy metal concentrations for Cr, Cu and Ni were found to be 0.10 mg/l, 0.11 mg/l and 0.19 mg/l dry weight, respectively. Surprisingly, Co and Cd metals were not detected at any station or at any season. Other water quality parameters, namely pH, turbidity and nitrate, fall in the intermediate value range for these measures. The comparisons of the measured parameters and the metal concentration with the water quality index show that the water quality of Acı Lake prevents the water being used as irrigation water due to high salt levels.

ZUSAMMENFASSUNG: Bestimmung einiger Verunreinigungsparameter, der Wassergüte und der Schwermetallkonzentrationen des Aci-Sees (Karapinar/Konya, Türkei).

Im Aci-See wurden die Gewässergüteparameter gemessen. Die Wasserproben wurden innerhalb von zehn Monaten an fünf Probestellen entnommen. Entsprechend den Ergebnissen der untersuchten Wasserproben – ohne Berücksichtigung der jahreszeitlichen und der standörtlichen Unterschiede- wurden die jährlichen Mittelwerte des Schwermetallgehaltes von Cr, Cu und Ni mit jeweils 0,10 mg/l, 0,11 mg/l und 0,19 mg/l Trockengewicht ermittelt. Überraschender Weise wurden die Schwermetalle Co und Cd innerhalb des Untersuchungszeitraumes an keiner der Probestellen vorgefunden. Messungen der pH Werte, der Trübung und Nitrate wurden als zusätzliche Gütewerte hinzugefügt. Der Vergleich der gemessenen Parameter und der Schwermetallkonzentration mit dem Gewässergüte-Index zeigen, dass das Wasser des Aci Sees aufgrund seines hohen Salzgehaltes für Bewässerungszwecke nicht verwendet werden kann.

REZUMAT: Determinarea parametrilor de poluare, calitatea apei și concentrația metalelor grele din lacul Acı (Karapinar/Konya, Turcia).

Parametri de calitate ai apei au fost măsurați pentru lacul Acı. Măsurătorile, au fost realizate pentru probe de apă din cinci stații pe parcursul a zece luni. Rezultatele arată, fără a lua în considerare diferențele sezoniere și stațiile, că valorile medii anuale a concentrațiilor de metale grele precum Cr, Cu și Ni sunt următoarele: 0,10 mg/l, 0,11 mg/l și 0,19 mg/l din substanța uscată. Nu au fost observate metale precum Co sau Cd în nici un sezon sau stație. Pe lângă acestea, pH-ul, turbiditates şi o concentrația de nitraţi au fost măsurate. Comparația concentrațiilor măsurate cu indicele de calitate al apei arată că apa din lacul Acı nu poate fi acceptată pentru irigare datorită nivelului ridicat de săruri.

INTRODUCTION

In many respects, water is one of the most important molecules in the world (Gleick, 1993). Conservation, usage and management of water supplies are therefore extremely important. After tropical jungles, wetlands are the second most important habitat for biological production and biodiversity conservation (Brinson et al., 1981; De Groot et al., 2006; Bănăduc et al., 2016). Especially, drought influence on soil moisture content cause a diminishment in wetlands and finally result in wetland loss, leading to disruption of ecological properties and processes, and a decrease in biodiversity (Poons et al., 2008; Wang et al., 2016). Not only global warming and climate change but also insensitive and uncontrolled industrialization as well as pollution and over-use of water are all causes of wetland loss. (Keddy, 1983)

Intense activity in the industrial and agriculture sectors in Turkey and elsewhere has inevitably led to increases in the levels of heavy metals in natural waters (Karadede et al., 2004). Fish and plants may accumulate large amounts of some metals from water. Accumulation patterns of contaminants in fish and other aquatic organisms depend both on up take and elimination rates (Hakanson, 1984; Karadede et al., 2000). For these reasons, it is important to determine the concentrations of heavy metals in commercial fish in order to evaluate the possible risk of fish consumption for human health (Cid et al., 2001).

The aim of this study is to explore the reasons for the deterioration of the natural resources around Acı Lake, Turkey, and especially to explore thoroughly the reasons for the decrease of the water level of the lake. Acı Lake, which is volcanic-based and a salty water source, is an important habitat for birds and other creatures. Thus, through this study, some important precautions will be determined to protect Acı Lake, which is classified as one of the most important geological sites and accepted to be an important wetland in the region.

MATERIAL AND METHODS

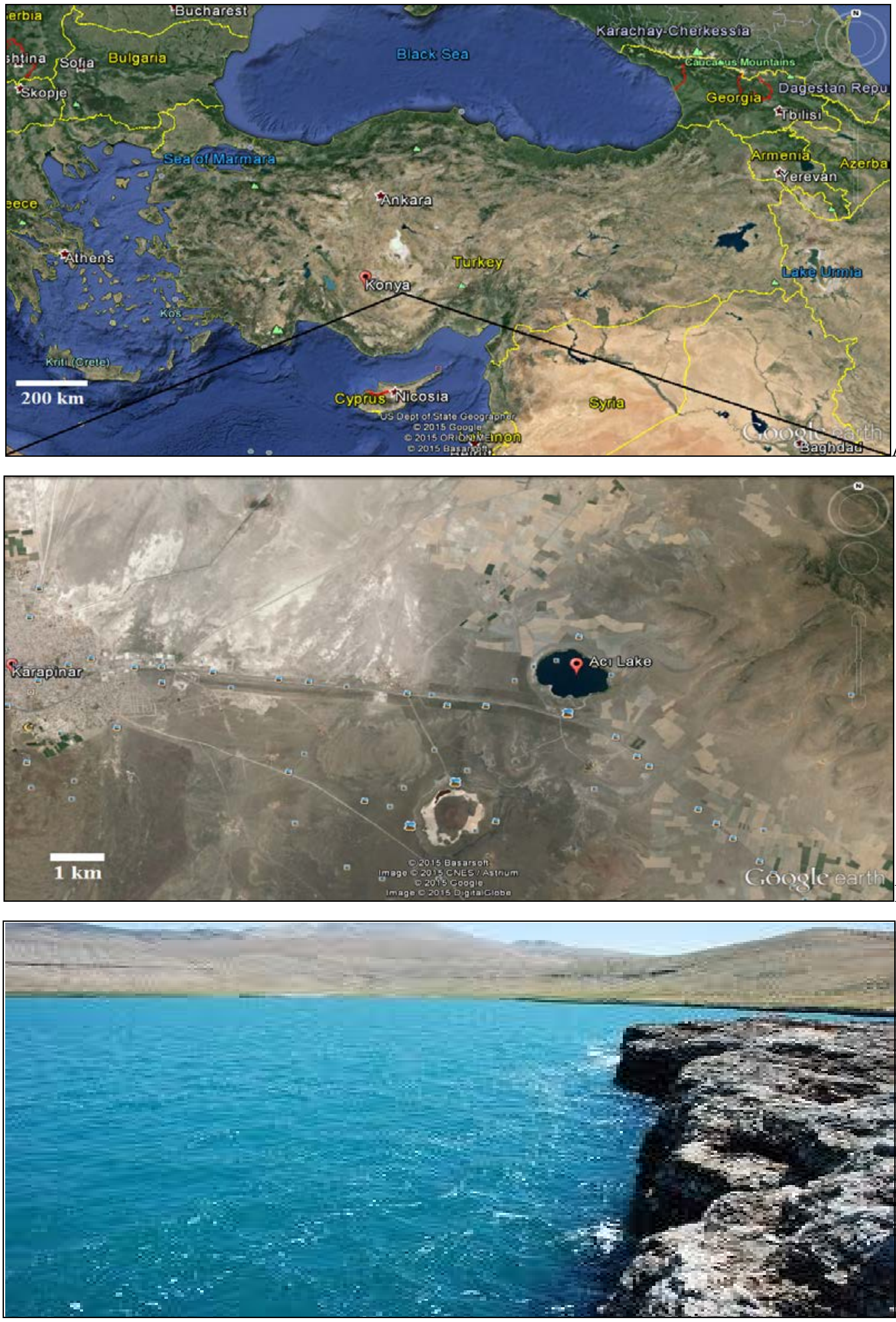
Study site

Acı Lake (Figs. 1A-C), which is our research area, is 108 km north east of the regional capital, Konya and eight km north east of Karapınar, close to the Adana Highway (Fig. 1A). Acı Lake is 200 m deep. The source of the lake is rain and groundwater sources. Water from Acı Lake contains sulfur salts, giving it a salty and bitter taste. Acı Lake is one of the deepest lakes in the area, and is closest to Konya.

Water sampling method

In this case study, to determine the level of pollution and the quality of the water in Acı Lake, during the years of 2005-2006, monthly water samples (Fig. 2) of the lake were taken. The study was conducted in four different stations chosen from Acı Lake, to take the water samples. Samples were taken once a month.

In the previously determined station areas, nearly five m distant from the shore, water samples were taken and put into 500 ml plastic bottles. HNO_3 in the proportion of 65% were added to the samples that had been taken (Cataldo et al., 2001). The samples, by being put into transport containers, which include ice masses, were protected from external factors such as daylight and heat, and they were brought to the laboratory in this manner within the same day. While the samples of the sediments were kept frozen at –18°C till they are analysed, the samples of water were kept refrigerated at 10°C.



A.

B.

C.

Figure 1: The Acı Lake satellite image A (Google Earth), schematic map B and image C.

Heavy Metal Analysis in the Water Samples

First and foremost, to prevent cross-contamination, the materials that were used in the study were washed in water prepared with 0.69% HNO_3 and deionized water, and then they were dried in the drying oven. The samples of the water were poured through 100 mm blue band filter paper into a Falcon tube until a volume of 25 ml was reached.

Figure 2: Sampling station in Acı Lake.

Data analysis

The statistical analysis programme SPSS 15 was used to carry out statistical calculations. One-way ANOVA post-hoc tests (Duncan) were used to determine the differences between seasons and stations in the samples of water and to determine the differences between tissues taken from the fish samples.

RESULTS AND DISCUSSION

According to the results of the analyses done in the water, without taking into consideration the difference of season and stations, the average values of heavy metal concentrations for Cr, Cu, and Ni were found to be 0.10; 0.11; and 0.13 mg l^{-1} respectively per year. Cd and Co metals were not found in any station in any season in this study. In the following tables, the seasonal station averages (Seasonal Averages, Tab. 1) and station annual averages (Stational Averages, Tab. 1) of the identified metals are given.

The following parameters are made use of in determining the quality of the lake's water: Cr, Cu and Ni were measured as heavy metals in this study. Although the value of these elements is higher in some months than others, as shown in figure 3, on average these heavy metals were present at a concentration of approximately 0-0.2 mg/l. As compared with each other, every third metal is high at the same time. Each of them has different peak months. Quality regulations for potable water permit levels of Ni with Cr up to a maximum of 0.1 mg/l and Cu up to 1.3 mg/l. This value is slightly higher in surface waters of high quality (Yskyy, 2012). Measured values of Cr under this limit are also close to the values of other metals, and close to the maximum limit. These findings indicate that the contamination of water in Acı Lake is not very great, indicating that heavy metal pollution is not a serious issue.

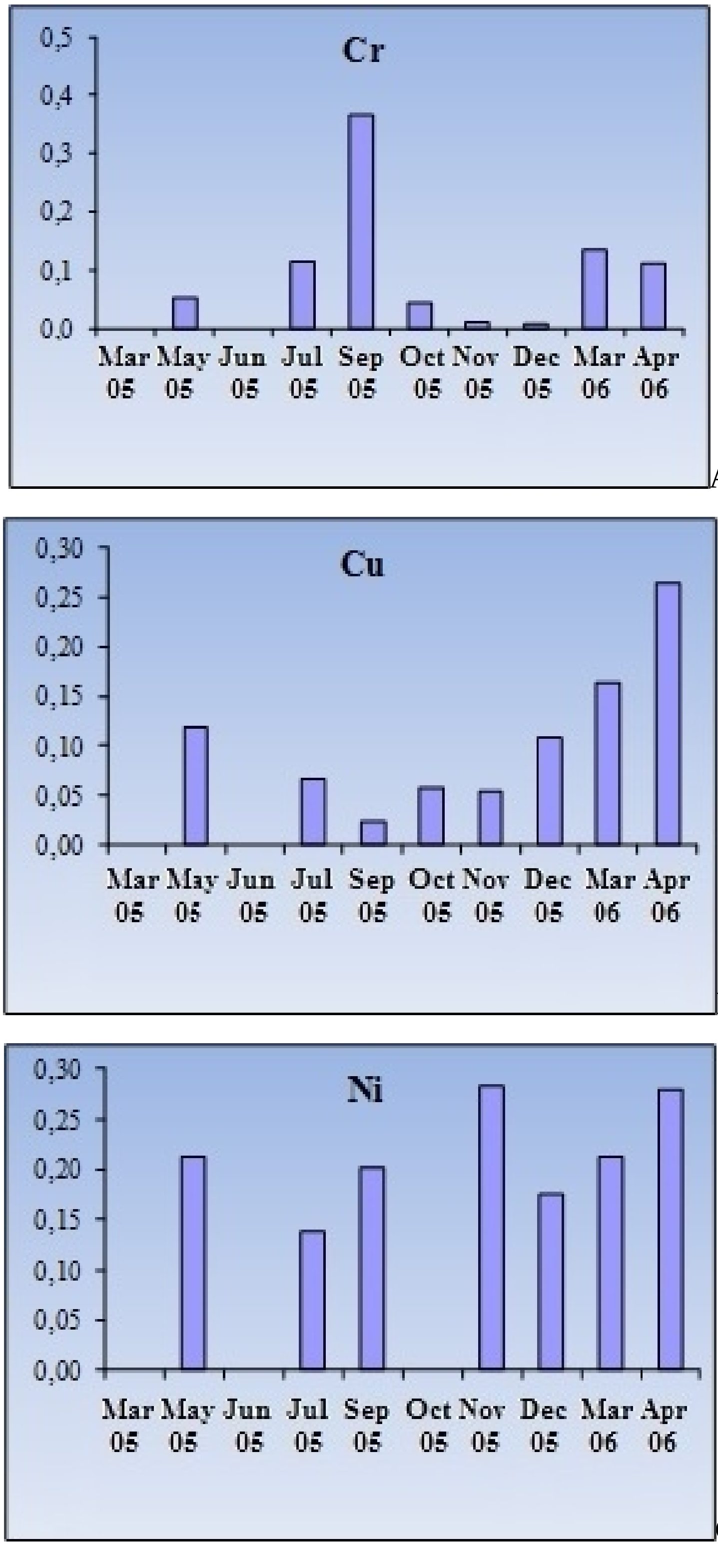


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Figure 3: The levels of heavy metals in Acı Lake.

Table 1: The monthly average values of Acı Lake's water's physical and chemical characteristics.

Date	March 2005	May 2005	June 2005	July 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	March 2006	April 2006	Average
pH	7.9	7.7	7.5	7.7	7.7	7.6	7.7	7.7	7.8	7.9	7.7
Dissolved oxygen (mg O_2/l)	0.75	0.73	0.7		0.05	0.2	0.24		0.21	0.23	0.34
Muddiness (NTU)	6.28	6.53	2.66	3.71	8.87	2.82	1.61	3.55	11.53	5.4	5.82
TSS (mg/l)	209	535	775	50	22	5	390	555	299	235	281
TSM (mg/l)		79.190	73.718	81.668	70.410	74.748	13.447	73.540	70.073	69.900	81.761
Oil and grease (mg/l)	765	1,123	3,632	970	3,819	3,870		4,053	629	821	2,154
Acidity (mg/l)	103.12	182.50	115.00	16,750	19,000	24,750	35,750	19,750	20,500	15,500	52,609
Alkalinity (mg/l)	103.75	172.50	165.00	56,250	40,250	71,000	71,000	41,000	19,000	14,250	66.594
Ca^{++} Solidity (mg/l)	18,125	40,625	40,625	11,125	15,500	11,625	17,125	12,000	12,875	13,750	17,703
T. Solidity (mg/l)	61,875	68,125	42,500	28,500	34,250	25,375	93,125	24,625	26,375	28,375	45,266
Chloride (mg/l)	286.87	32,500	6,250	6,625	49,250	32,500	72,000	85,000	33,250	42,250	79,203
SO_4 (mg/l)	101.01	2,016	10,887	6,855	11,694	2,981	51,411	20,565	12,298	4,032	25,751
Org. Subst. (mg/l)	2,625	1,625	1,750	1,500	3,625	1,625	1,100	4,225	688	1,050	2,070
COD (mg/l)	108.00	40,000	92,000	1,600	96,600	140.00	108.00	76,000	14,400	164.00	93,375
BOD (mg/l)		21.04	2.47		14.66	7.75	1.25		2.5	3.5	8.45
NO_3-N (mg/l)	0.25	0.05	0.08	0.02	0.02	0.16	0.02	0.02	0.09	0.03	0.08
NH_3-N(mg/l)	3.2	22.16	29.94	13.92	11.9	15.27	10.18	15.72	15.12	11.38	13.12
TP (mg/l)	2.46	0.21	0.45	0.02	0.01	0.14	0.02	0.01	0.07	0.05	0.37
Chl-a ($\mu g/m^3$)	4.67	5.14	8.78	3.74	0.56	79.43	1.87	12.15	23.83	2.24	16.24
Cr (mg/l)		0.05		0.12	0.36	0.04	0.01	0.01	0.13	0.11	0.1
Cu (mg/l)		0.12		0.07	0.02	0.06	0.06	0.11	0.16	0.26	0.11
Ni (mg/l)		0.21		0.14	0.2	0	0.28	0.18	0.21	0.28	0.19

The solubility of a number of gases such as oxygen changes with temperature. Acı Lake is subject to significant variations in temperature (Tab. 4). In the summer, where there are high temperatures, oxygen solubility decreases at the same time as increased biological activity causes the use of an enormous amount of oxygen especially in surface waters, sometimes leading to oxygen depletion. As a result of measurements performed in the Acı Lake, oxygen depletion has been identified during the period of highest temperature, in July (3rd station). The lowest temperature was measured at the third and fourth stations in December. Measurements could not be taken in January and February because the lake is completely frozen. The measured temperature range is necessary to maintain the aquatic ecosystem of the lake.

The hydrogen ion concentration is an important parameter for water resources. The range of hydrogen ion concentration suitable for biological life is quite narrow: a pH value between four to nine is required for the survival of life in the water. The majority of natural water is slightly alkaline due to carbonates and bicarbonates. The water sampled from Acı Lake falls in the neutral and very slightly alkaline pH range (pH seven to eight, Fig. 4). In May and June (2005) both acidity and alkalinity are quite high. This situation in the neutral pH condition indicates that there is more mineral content as well as dissolved carbonate present, giving the water a high buffering capacity.

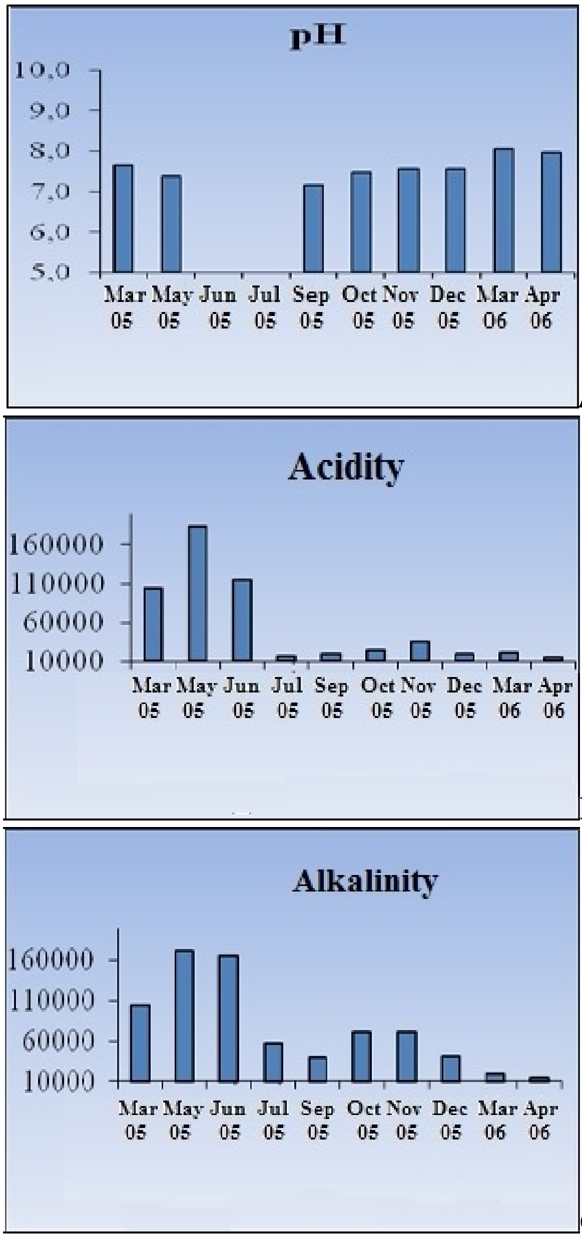

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Figure 4: The pH values of Acı Lake.

Aerobic microorganisms in water and other aquatic organisms produce energy by utilizing oxygen, and they need access to appropriate levels of oxygen in accessible formats, such as dissolved oxygen. In lake Acı dissolved oxygen (DO) values are less than one mg/l when sampled all months (Fig. 5). This situation affects adversely the quality of the lake water. It must be present at least two mg/l dissolved oxygen for aerobic microbial activity.

Table 2: The temperature rates of Acı Lake.

	April 2006	May 2006	June 2005	July 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	March 2006	April 2006
1st station	11.1	14.6	24.8	25.7	21.2	17.6	8	9	9.1	11.1
2nd station	11.3	15.3	24.8	26	23.1	18.4	9	8	10.5	11.3
3rd station	11.5	15.7	24.8	26.3	23.4	18.3	9	7	10.2	11.5
4th station	11.1	14.8	21	25.7	23	18	8	7	9.2	11.1
	April 2006	May 2006	June 2005	July 2005	Sept. 2005	Oct. 2005	Nov. 2005	Dec. 2005	March 2006	April 2006
1st station	11.1	14.6	24.8	25.7	21.2	17.6	8	9	9.1	11.1

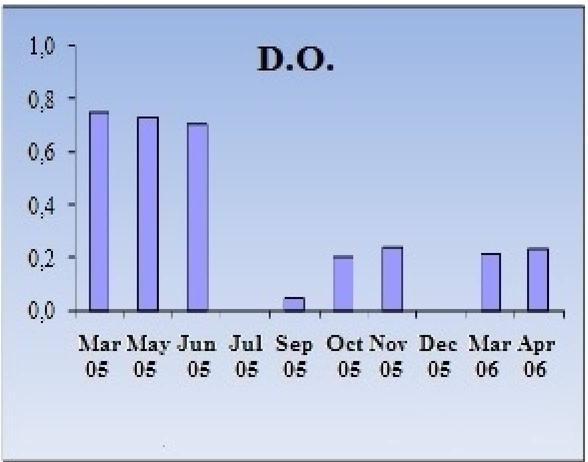


Figure 5: The Dissolved Oxygen Rates of Acı Lake.

Chemical oxygen demand (COD) is one of the most important parameters to use for determining the degree of pollution of domestic and industrial waste water. Although biochemical oxidation occurs very fast in some organic matter, the amount of organic matter is measured as chemical (which may be oxidized in an acidic environment with dichromate) in chemical oxidation. COD is one of the most commonly used parameters in studying environmental pollution. The average domestic wastewater COD values are between 400-600 mg/l. The low level of DO indicates pollution in Acı Lake water. Therefore, high COD values are also expected, which is indeed observed in the samples (Fig. 6), with samples indicating a high level of organic pollution in Acı Lake.

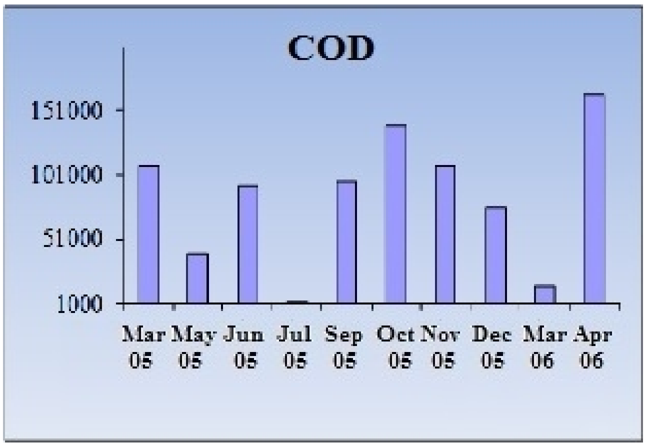


Figure 6: Acı Lake's Chemical Oxygen Requirement Rates (COD mg/l).

Biochemical oxygen demand (BOD) is the amount of oxygen which necessary to stabilize the bacteria breaking down organic substances under aerobic conditions. Five-day BOD is the most frequently used parameter to identify organic contamination in waste water and surface water samples. BOD is based on aerobic oxidation and it a living test (bioassay) using organic nutrient substances and measuring the consumption of oxygen by mixed microorganism at 20°C. In domestic wastewater, the BOD/COD ratio is approximately 0.6-0.65. Despite its widespread use, there are some disadvantages of this method; it requires a bacterial vaccine for species with high levels of activity and which are accustomed to waste water, pre-treatment requirements for toxic wastewaters, a requirement for nitrification inhibition, only the biodegradable material can be measured, and it takes a long time in comparison with other tests. Although BOİ data could not be obtained for all samples, those values that were obtained indicate that the BOD/COD ratio is incompatible with domestic water (Fig. 7). BOD values were observed to be quite low compared to COD. This is a sign that it is a bit different from the type of biodegradable organic material type. In this case, contamination is a more serious problem.

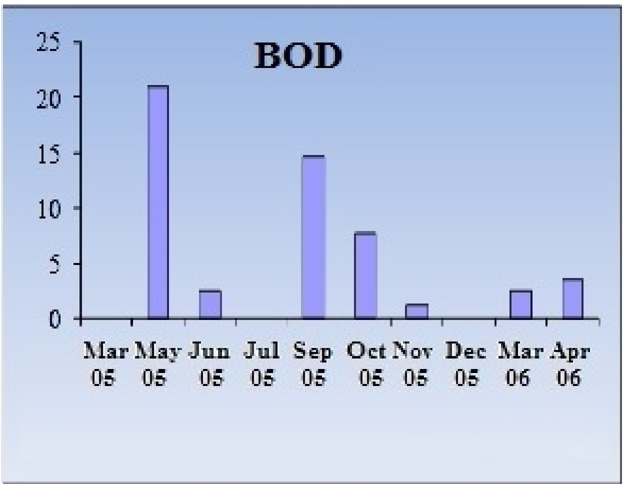


Figure 7: Acı Lake's Biochemical Oxygen Requirement Rates (BOD mg/l).

Suspended or dissolved materials in natural water and waste water are called solids. Water containing a high percentage of solids is not used for drinking water or for industrial purposes. Based on the results reported already in this paper, a high value of the CDM is to be expected in Acı Lake water. It was determined from the acidity and alkalinity data that the amount of dissolved mineral and ions in the water is high. Accordingly, the total solid (TS) level is high. Total dissolved solids data are presented in the next section along with levels of sulphate and chloride values which are salinity indicators and may help explain the findings. Based on the geological structure of Acı Lake and the environment, it is to be expected that salinity and TSM are high.

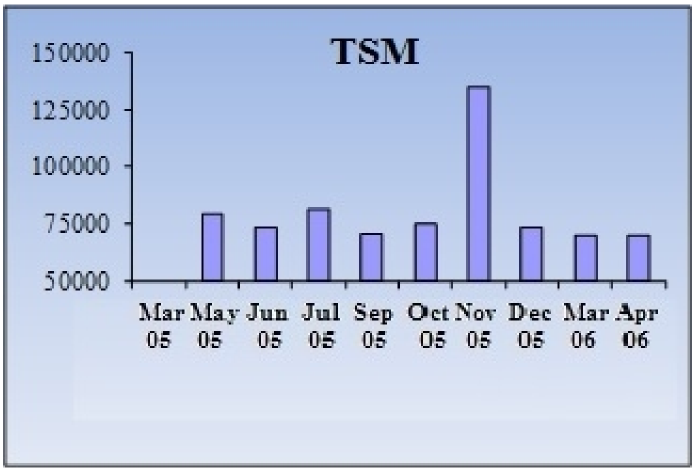


Figure 8: Acı Lake's Total Solid Matter (mg/l) Rates.

When figures 7 and 8 are evaluated together, it is seen that the total solids in the lake form a very small portion of the Total Suspended Solids (TSS). TSS values are an approximate value of domestic wastewater and this property is the result of the combination of the underlying geology of the lake, a travertine structure, and possible pollution status. In spring and autumn this value can be higher than in other seasons due to vertical mixing in lake water, eliminating stratification and evenly distributing TSS throughout the lake.

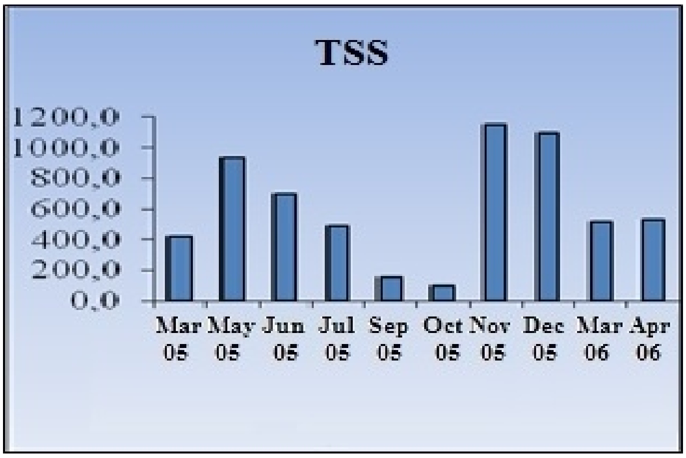


Figure 9: Acı Lake's Total Suspended Solids (mg/l) Rates.

Colloidal substances in water and suspended solids deposition create turbidity. It is measured by the turbid meter. Natural water is never as clear as pure water, because there are dissolved substances, microscopic creatures, suspended particles and so forth. Turbidity values of samples from Acı Lake are quite low, approximately in the range of 2-11 NTU (Fig. 10). In line with previous findings, dissolved solids pollution seems to be higher than solid pollution.

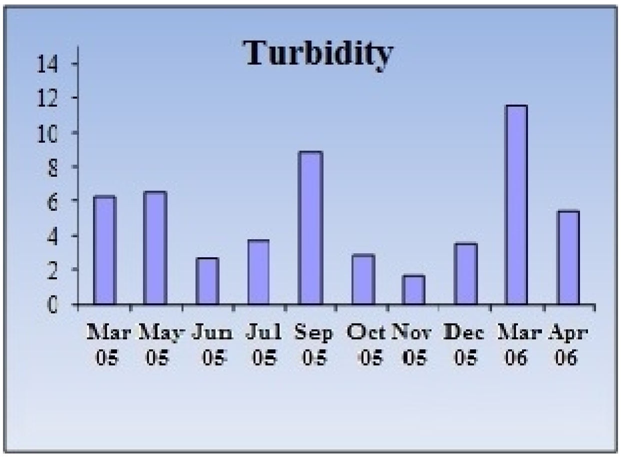


Figure 10: The rates of turbidity.

Oil and grease both have limited solubility in water and a tendency to leave the water phase, making these two types of substances important. The oil-grease is a parameter typically measured in wastewater and sewage treatment plants. Normally oil-grease is present in surface waters due to unexpected causes, and therefore it does not typically exist among the analyzed parameters in routine analysis. But, considering the levels of organic matter and mineral contaminants described in the above sections in Acı Lake, this parameter was evaluated for verification purposes. As shown in figure 11, values of oil-grease vary from 630 mg/l to over 4,000 mg/l. Values of DO are low, generally have higher concentrations of organic substances especially that high in the months make strong judgment of wastewater pollution which is non-domestic origin.

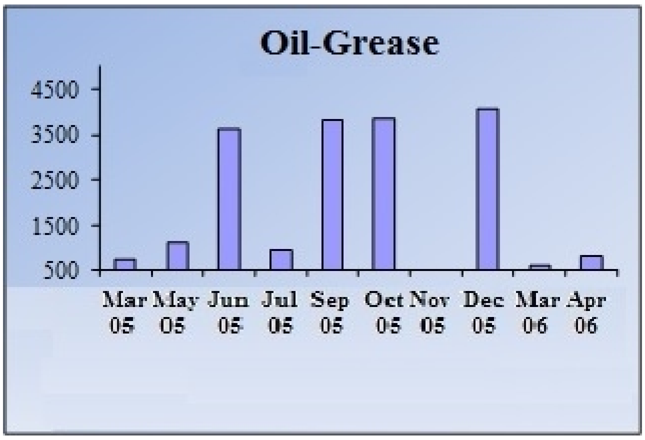


Figure 11: The rates of oil-grease.

If there is no oxygen or nitrate in a rich environment, then anaerobic bacteria tend to dominate in breaking down organic substances. This typically produces sulfate ions and bacteria benefit from the oxygen that is produced in the process. Consequently, sulphate ions combine with hydrogen ions, creating hydrogen sulfide, a source of many problems such as corrosion and smell. Sulfate anion is one of the most common forms of sulfur in fresh waters, as it comes from sulphate-rich sediments eroded by rain. However, sulfate is not very common in surface water. The lack of a sufficient supply of sulphate in water inhibits phytoplankton growth, and therefore biological yield decreases. As shown in figure 12 the highest sulphate values in Acı Lake were observed in spring (March) and autumn (November). The maximum limit of sulphate in water for human consumption is 250 mg/l, so the results presented here indicate that the maximum measured values of sulfate is not surprising given the mineral content and the high amount of organic pollution. On the other hand, soluble sulphate depends on the structure of rocks in the region, which is known to contain rocks with permanent hardness components such as $^{2+}$ bivalent Ca and Mg ions. These are known to bind to ions such as sulfate and chloride, so an excess of sulfate indicates the presence of these compounds.

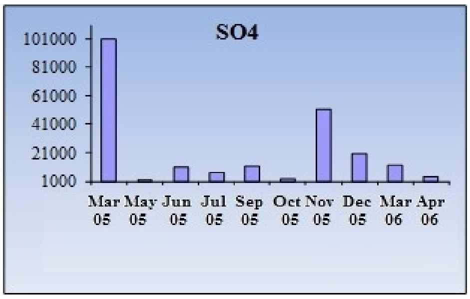


Figure 12: Acı Lake’s Sulfate concentration (mg/l).

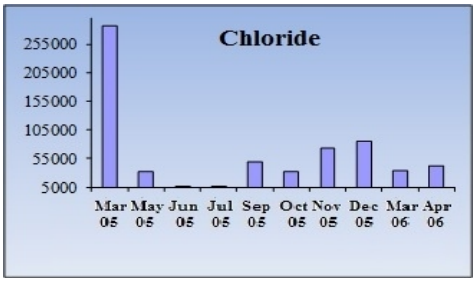
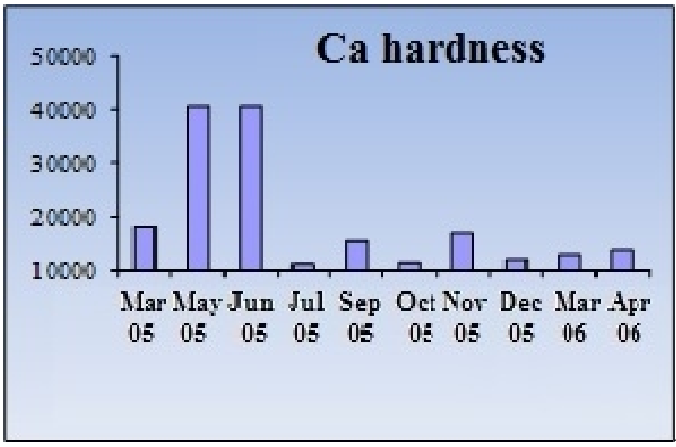


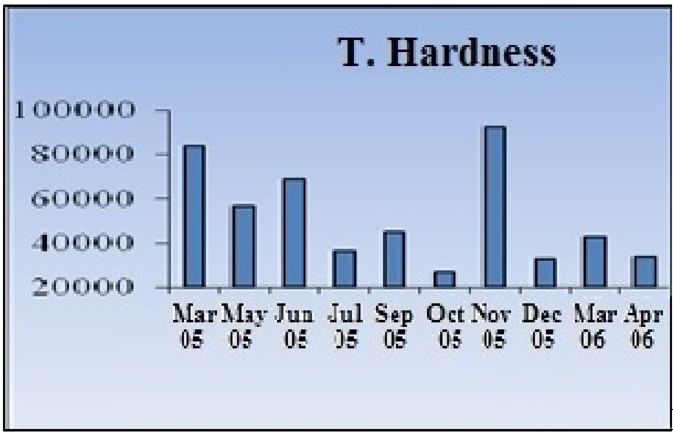
Figure 13: Acı Lake’s Chloride (mg/l) Rates.

Chloride ions (Cl) are found in almost all natural waters in various concentrations. Because chloride is readily soluble in water, there are often many chloride salts present in natural water. Chloride can also come from waste water. While concentrations higher than 250 mg/l chloride in drinking water is not allowed, chloride may be allowed up 2,000 mg/l in water used for other purposes. Chloride is closely related to salinity and electrical conductivity. As the chloride concentration increases, these other parameters will also increase. High levels of salinity in water resources used for potable water are not ideal, because treatment is costly. Chloride values in Acı Lake are high, with the highest value measured in March 2005, as 2.9*105 mg/l (Fig. 13). All chloride values were over 2,000 mg/l in the period studied. The average chloride value was 55,000 mg/l. This situation of excess salinity is in line with the region’s underlying geological structure and mineral content. While supporting the existence of pollution, it also points to the permanent hardness components of the water from the rocks.

The water hardness occurs largely as the result of contact with soil and rocks. Hard water has several drawbacks: hard water requires much soap usage by preventing the soap foaming and it leads to the formation of scales on the inner walls of pipes at high temperatures. When it comes to the total hardness of water, this is influenced by a number of alkaline earth ions in water, and also strontium and barium ions. Water is considered "hard" when it contains over 300 mg/l $CaCO_3$. Hardness is regarded as the most important component of the Ca ions when considering rock structures. C hardness and total hardness were measured separately to determine how much of the hardness in Acı Lake is the result of Ca in samples. It was found that Ca varied from 11,000 mg/l $CaCO_3$ up to 41,000 mg/l $CaCO_3$ with an average value of 24,000 mg/l $CaCO_3$ and a maximum value of 94,000 mg/l $CaCO_3$ (Fig. 13). The most important result from measuring this parameter is that although the lake water is very hard, the majority of the hardness is not from Ca, except in the months of May and June. Concentrations of strontium, an ion which also causes hardness, are also present in high concentrations. When given the above data on acidity and alkalinity, it becomes clear that water hardness in lake Aci is caused evenly by both carbonate hardness (temporary hardness caused by Ca) and non-carbonate hardness (permanent hardness caused by an excess of chloride and sulphate forms).



A.



B.

Figure 14: Acı Lake's Total Hardness (mg $CaCO_3$/l) Rates.

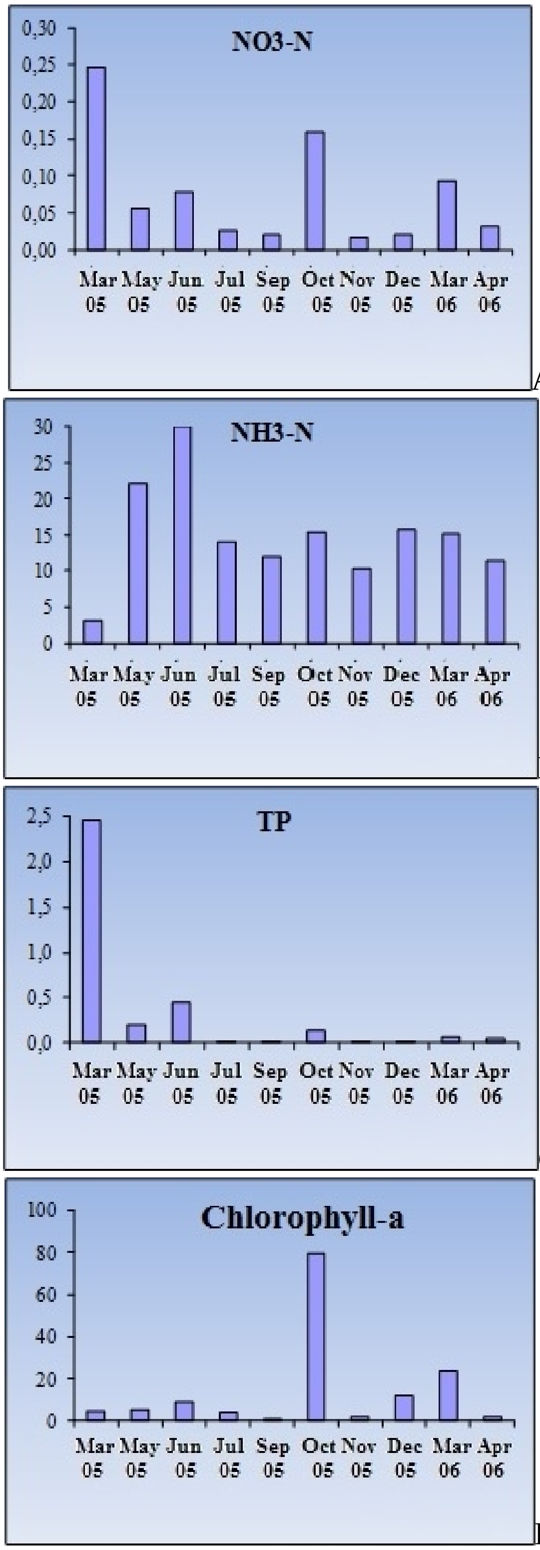
Many of the nutrients involved in water pollution, especially nitrogenous substances, are priority pollutants. Nitrogen has a natural circulation in water sources, in the atmosphere, in plants and animals, and it forms different compounds. It is a nutrient material which is necessary for the survival and reproduction of almost all living cells. Nitrogen with phosphorus is very important as a food (nutrient) source in microbiological and algal growth in water sources. Algal growth can occur undesirably in water supplies contaminated with excess nutrients. Three types of water-soluble nitrogen, namely ammonium, nitrate and nitrite, have environmental importance. Nitrite (NO_2), because it is a temporary phase ion, is often minimally present in water. Nitrate (NO_3) has been the most researched of the nitrogen forms, yet it is one of the most difficult ions to measure. Nitrogen species indicate both the presence of contamination and whether it is recent or old pollution. When wastewater is newly discharged, organic nitrogen is most common. Over time, this turns into first ammonia nitrogen, and then if the environment remains aerobic, into nitrite, then into nitrate. This transformation is achieved by autotrophic bacteria using DO in the environment, which causes the DO concentration to decrease. Ammoniacal nitrogen values are relatively high compared to the concentration of nitrate in Acı Lake (Figs. 14a-b). Hence, the results obtained indicate that the pollution of the lake is new, because otherwise anoxic conditions in the lake would predominate (DO to be close to zero), and denitrification would take place efficiently.

Total phosphorus found was high (TP) only in March (2005). At other times it was very low (Fig. 15C). Because many of the other parameters were also significantly higher in the same month, in March 2005, this indicates the possibility of an immediate discharge of waste water into Acı Lake. The highest TP is about 2.5 mg/l, but the average was observed between 0-0.5 mg/l. When compared with nitrogen data, to prevent an increase in the level of algal growth, there needs to be an adequate level of TPI. Chlorophyll A values are generally low, peaking in October 2005 (Fig. 15D). This can be explained by algal blooms occurring in the autumn. In contrast, the lake is not very rich in algal biomass. These results indicate that at present, there is no case of eutrophication but that there is a risk of it in the future.

CONCLUSIONS

Temperatures in Acı Lake fall within a suitable temperature range to maintain the vibrant life of aquatic systems. Both acidity and alkalinity are quite high. With a neutral pH, this situation indicates that water soluble carbonates, as well as the mineral content, are high in concentration, indicating a high buffering capacity of the water. It is seen that the TSS forms only a small portion of the total solids. TSS values are approximately the same value as domestic wastewater and it confirms that there are pollution problems in the lake. Turbidity values of samples from Acı Lake are low, approximately in the range of 2-11 NTU. Solid analysis confirms that pollution is present.

Measured values of chloride and sulphate are in line with the other observations of excess mineral content and support the presence of contamination. However, the underlying geology of the region, consisting of soluble rocks in natural waters, are also important in understanding the measures of permanent hardness of the lake water, and depends on which Ca and Mg^{2+} ion valences are formed with sulphate and chloride ions. High levels of sulphate ions indicate to the presence of these compounds. Having extremely high level of hardness in water samples supports this finding. When acidity and alkalinity are assessed with other measures of water quality, it indicates that Lake Aci experiences both carbonate hardness (temporary hardness) and non-carbonate hardness (permanent hardness) from high levels of chloride and sulphate.



A. B. C. D.

Figure 15: Concentrations of nitrogen, phosphorus and chlorophyll in Acı Lake.

Dissolved Oxygen values are less than one mg/l when sampled across all months. This situation adversely affects the quality of the lake water. DO must be present in concentrations of at least two mg/l dissolved oxygen for aerobic microbial activity to take place. On the other hand, samples indicate quite high COD levels above the average 400-600 mg/l permitted in domestic waste water – indicating organic pollution in Acı Lake. There were very low BOD values observed compared to COD. This indicates that the type of biodegradable organic matter is slightly unusual, and may indicate a more serious problem. Normally oil-grease is not expected in surface waters, and does not form part of routine water quality analyses. But, considering the organic matter and mineral contaminants as described in the above sections in Acı Lake, this parameter was evaluated for verification purposes. Values of DO are low, and generally reflect higher concentrations of organic substances, strongly suggestive of wastewater pollution which has a non-domestic origin. Ammoniacal nitrogen values are relatively high compared to the nitrate nitrogen in Acı Lake (15A-B). Hence, results were obtained that the pollution of the lake is new or anoxic conditions in the lake (DO to be close to zero), denitrification takes place in an efficient manner. In the other direction it was not very rich algal biomass lake. At present, there is no case of eutrophication but there is a high potential of it occurring in the future without remediation of the existing water quality and management.

There are several options for the future management of lake Acı, notably the need for afforestation, not only to control the erosion there, but also to provide shelter, reproduction opportunities and nourishment possibilities to the members of that particular area’s fauna. Thus, it is recommended that suitable bushes and trees are planted in the area, to reduce the risk of pollution.

ACKNOWLEDGEMENTS

This work is supported by The Research Foundation of Selcuk University (project number: 14401085).

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HABITATS WITH LARGE BITTER CRESS (*CARDAMINE AMARA* L.) IN THE SPRING AREA OF NERA RIVER (SEMENIC MOUNTAINS, ROMANIA)

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DOI: 10.1515/trser-2017-0002

KEYWORDS: springs, seepage area, clear water habitats, hydrophilous plant communities, oligothermic condition.

ABSTRACT

The paper presents the spring habitats and their communities edified by the Large Bitter Cress (*Cardamine amara* L.) in the area of Nergăniţa, a headwater stream of the Nera River included in the “Nature Reserve Semenic Mountains and springs of Nera River”. The communities of Large Bitter Cress are situated in and on the springs and spring streamlets situated in the beech forest area, being well adapted to the special site conditions with low water temperatures, low light conditions and humus rich soils. The species composition of the Large Bitter Cress communities and their habitats are presented in strong relation with the habitat conditions and the interrelation with other communities. Finally, the conservation status of the streamlets habitats is analyzed in the context of their importance for the European Natura 2000 network.

ZUSAMMENFASSUNG: Habitate des Bitteren Schaumkrauts (*Cardamine amara* L.) an Quellbächen der Nera, Semenic-Gebirge, Rumänien.

In vorliegender Arbeit werden die Habitate der Quellen und Quellbächlein sowie die von Bitterem Schaumkraut (*Cardamine amara* L.) aufgebauten Gesellschaften im Einzugsgebiet des Nergăniţa Baches, ein Hauptquellzufluss der Nera im “Naturschutzgebiet Semenic Gebirge und Nera Quellen” vorgestellt. Die Bestände des Bitteren Schaumkrauts liegen an und in den Quellen und Quellbächlein inmitten von Buchenwald und sind an die Standortbedingungen: niedrige Wassertemperaturen und Lichtverhältnisse sowie humusreichen Boden gut angepasst. Die Artenzusammensetzung der Gesellschaft von Bitterem Schaumkraut und ihr Lebensraum werden in enger Verbindung mit den Habitatbedingungen sowie den Beziehungen zu anderen Gesellschaften vorgestellt. Schließlich wird der Schutzstatus der Quellflur Habitate im Kontext ihrer Bedeutung für das Natura 2000 Netzwerk analysiert.

REZUMAT: Habitatele de stupitul cucului (*Cardamine amara* L.) în aria pârâiaşelor-izvor ale Nerei, Munţii Semenic, România.

Nergăniţei este afluent principal al râului Nera din „Rezervaţia Naturală Munţii Semenic şi izvoarele Nerei”. Grupările de stupitul cucului sunt situate în şi în jurul izvoarelor şi a pârâiaşelor-izvor din pădurea de fag, fiind bine adaptate la condiţiile staţionare caracteristice: temperatură scăzută a apei, lumină redusă, precum şi soluri bogate în humus. Componenţa specifică fitocenozelor edificate de stupitul cucului şi habitat sunt prezentate în strânsă legătură cu condiţiile de habitat şi în relaţie cu comunităţile învecinate. Statutul de conservare este discutat în contextul importanţei habitatului pentru reţeaua Natura 2000.

INTRODUCTION

The forest area of the Semenic Mountains in the “Nature Reserve Semenic Mountains and springs of Nera River”, part of the National Park Semenic Mountains-Gorge of Caraş (Parcul Naţional Semenic-Cheile Caraşului), Caraş-Severin County in the South-Western part of Carpathians, is sheltering many spring-streamlets frequently in small channels or as larger seepage areas on the slopes of the valleys. These streamlet areas are characterized by water tresses surrounding stones, loose gravel patches with humus soils and on the surface with layers of under composed leaf litter from the antecedent year. They are characterized by plant species adapted to cold and clear waters, like large bittercress (*Cardamine amara* L.), mentioned as occurring “in wet forests, ditches, around springs, in swampy sites, on the border of streams, quite frequent from the plaines to the sub-alpine level” (Nyárády, 1955). On the list of localities with occurrences of the species in Romania for the Semenic Mountains the species is given “in bogs” without any precise locality (Nyárády, 1955). The altitudinal distribution of the species reaches from the plainer to the hilly, pre-mountain to the higher mountain and subalpine levels (around 1,700-1,900 m), being more frequent on the higher levels of the mountains (Oberdorfer, 2001).

According to additional data concerning ecological requirements as the above mentioned, the species is given (as characteristic for spring areas), alder swamp forests, streamlets and ditches, on wet clay soils with cool, nutrient rich and alkaline seepage water. Also, it is mentioned for more or less regularly flooded soils, but being able as well to survive temporarily without surface running water only on wet, muddy, alkaline and humus soils (Ellenberg et al., 2001; Oberdorfer, 2001).

From the phytocoenological point of view the bittercress (*Cardamine amara*) is mentioned as characteristic species of the class Montio-Cardaminetea Br.-Bl et Tüxen 1943, Ordre Montio-Cardaminetalia Pawlowski 1928, including the alliances Cardaminion amarae Mass 1959 and Cardamino-Montion Br.-Bl. 1926 (Oberdorfer, 2001; Sanda et al., 2008), but it occurs also in phytocoenoses of the alliance Alno-Ulmion Br.-Bl. et Tüxen 1943 em. Th. Müller et Görs 1958, including the sub-alliance Alnenion glutinoso-incanae Lüdi 1921 (Oberdorfer, 1992). The classifications for the order and the subunits, alliances, and sub-alliances are different according to the opinion of different authors (Coldea, 1978).

The alliance, Cardaminion amarae, includes the association Cardamino-Chrysosplenietum alternifolii Maas 1959 with the characteristic species *Cardamine amara, Carex remota, Chrysosplenium alternifolium, Conocephalum conicum, Impatiens noli-tangere, Oxalis acetosella* and *Plagiochila asplenioides* (Boşcaiu, 1971). With an increase of altitude, the floristic composition is changing, the phytocoenoses being more and more interlocked with elements of the tall herbaceous vegetation of Adenostyletalia order of the subalpine level. The phytocoenoses mentioned from Cerna Mountains at the Lunca Berhinei shelter beside the above mentioned species and two other species with subalpine-alpine distribution such are *Tozzia alpina* and *Barbarea lepuznica* (Boşcaiu, 1971).

The alliance Cardamino-Montion Br.-Bl. 1926 includes the spring streamlets phytocoenoses of sites with siliceous underground and deficiency in lime, being characterized by species such are *Chrysosplenium alternifolium*, *Chrysosplenium alpinum*, *Cardamine amara* incl. ssp. *opizii*, *Saxifraga heucherifolia*, *Stellaria uliginosa* and *Philonotis seriata*.

The habitats of springs and spring streamlets in the Romanian Carpathians are included in the habitat group of fens, bogs, springs, and streamlets, category 54 (Doniţă et al., 2005), with the types R 5418 South-Eastern Carpathian spring communities with *Philonotis seriata* and *Caltha laeta*, R 5420 Communities S-E Carpathians fontinale vegetation with *Cardamine opizii*, 5421 South-eastern Carpathian communities of springs and streamlets with *Chrysosplenium alternifolium* and *Cardamine amara*, 5422 Communities of South-Eastern Carpathian habitats of springs and streams with *Glyceria nemoralis.*

From these habitat types, the type R 5418 "South-Eastern Carpathian spring communities with *Philonotis seriata* and *Caltha laeta*" is included according to Gafta and Mountford (2008), in the Natura 2000 habitat type 3220 Alpine rivers and the herbaceous vegetation along their banks. As well the habitat R 5420, the South-Eastern Carpathian fontinale communities with Cardamine opizii and the habitat R 5423 South-Eastern Carpathian Communities of springs and streamlets with *Carex remota* and *Caltha laeta* (Doniţă et al., 2005), are included in the Natura 2000 Habitat type 3220 (Gafta and Mountford, 2008). But the R5421 habitat "South-Eastern Carpathian spring and streamlet communities with *Chrysosoplenium alternifolium* and *Cardamine amara*" is lacking in the habitat type 3220 of the Natura 2000 network: although there is locally a very strong interlocking with the other communities included in the mentioned habitat type and cannot be separated from their stands.

Considering these facts, the objective of the present paper is to close a gap with a presentation of montane phytocoenoses edified by *Cardamine amara* from the beech forest of "Nature Reserve Semenic Mountains and springs of Nera River", which differs from other studied Large Bitter Cress communities through its particular site conditions, and complete in the same time as the list of associations included in the corresponding habitat type of the Natura 2000 network in Romania.

MATERIAL AND METHODS

During the vegetation period of 2015, researches concerning the riparian habitats were realised in the Caraş and Nera river basins National Park Semenic Mountains-Gorge of Caraş (Parcul Naţional Semenic-Cheile Caraşului), and National Park gorge of Nera and Beuşniţa (Parcul Naţional Cheile Nerei-Beuşniţa). Special attention was given to the riparian vegetation from upstream to downstream, i.e. the riparian forest galleries (subject of another paper) the natural tall herbaceous vegetation, the pioneer communities on the banks and the river bed and as well the particular situation of the spring area of rivers. Samples were taken according to the method of Braun-Blanquet with the seven degree abundance-dominance scale, (Braun-Blanquet, 1964; Borza and Boşcaiu, 1965). Also considered were the aspects concerning the structure of the habitats in strong relation to the stream stretch and the water dynamics.

The samples taken are included in a phyto-coenological table and grouped according to characteristic species of the different phytocoenological units, their abbreviation being mentioned below in table 1. For the ecological analysis, indicator values for wetness (W), nitrogen (N), Light condition (L), are also considered (Ellenberg et al., 2001). The phytocoenoses are discussed in comparison with other mentioned communities edified by common watercress, (Oberdorfer, 1977; Sanda et al., 2008). The habitats are as well analysed and presented in the context of the European Union habitats, (EUR28, 2013; Gafta and Mountford, 2008; Doniţă et al., 2005). The nomenclature of species is used according to Sârbu et al. (2013), and Ciocârlan (2009).

RESULTS AND DISCUSSION

The spring area of Nergăniţa, a headwater stream of the Nera River presents a structured valley with many small spring-streamlets, forming frequently tresses around gravel escutcheons on an altitude of 1,100-1,300 m a.s.l. (Fig. 1). In the small valleys of the Nergăniţa sub-basin, the water is frequently seeping under the layer of different sized gravels mixed with the beech forest leaves and those decomposed from the preceded years, forming together a loose humus layer of various thicknesses. These all together constitute a wet channel complex with open, and by leaves covered cold, seeping or running clear waters, offering special conditions for plants adapted to such conditions, (Fig. 1). The most abundant species in this microhabitat inside the beech forest habitat is the large bittercress, (*Cardamine amara* R. Br.). The species occurs in the area under half-shadow to half-light conditions accompanied by other half-shadow species, (indicator values three-five according to Ellenberg et al., 2001), characteristic for beech (Fagetalia), forests or Grey Alder forest galleries (Alnion incanae), such are: *Chrysosplenium alternifolium*, *Scrophularia umbrosa*, and *Impatiens noli-tangere*. As well, characteristic species for tall herbaceous communities of clearings or forest borders which occur are *Lunaria rediviva* and *Doronicum austriacum*. According to Boşcaiu (1971a), *Impatiens noli-tangere* can be considered as a differential species for the lower montane levels of the association.

Figure 1: Spring streamlet in the sub-basin of Nergăniţa with typical vegetation of large bittercress (*Cardamine amara*), 2015.

In general, the structure of the phytocoenoses is given by the alternation of stones/gravels, water tresses and the large bittercress individuals, with the accompanying species being poorly represented, (Tab. 1, column 1-6). They are characteristic for the phytocoenological units of Fagetalia, Adenostyletalia, Molinietalia and mainly the alliances Filipendulion and Alnion incanae. The low number of species is given by the shadow conditions of the forest and the cold seeping water of the area, being a limiting ecological factor for species which are not adapted to such conditions.

The *Cardamine amara* phytocoenoses are included in the association Cardaminetum amarae (Rübel, 1912), Br.-Bl. 1926 s. str. which is synonymous with Chrysosplenio-Cardaminetum (Tx. 1937), Mass. 1959 (Drăgulescu, 1986, 1995; Boşcaiu 1971a, 1971b). The samples taken in the Nera River spring area have different characteristics from those described from other areas of the Carpathians, (Boşcaiu, 1971a, 1971b; Coldea, 1978; Drăgulescu, 1986, 1995). The differences are given by their existence in the forested area with special conditions of light, and the species living almost in half-light conditions with a small number of other accompanying species adapted to half-light conditions (Ellenberg et al., 2001). The floristic composition of the studied phytocoenoses is relatively stabilized by an ecological homeostasis, which is in strong dependence with the low, but continuous discharge, and the low and more or less constant temperature of the water and running water, with oligothermic regime, mostly along the vegetation period being only around 5°C, (Boşcaiu, 1971a).

On the forest border and in contact with the streamlet community, with *Cardamine amara*, are some larger escutcheon like seepage area with high abundance-dominance of *Filipendula ulmaria*, *Caltha palustris*, *Geum rivale* (Figs. 2 and 3). In that area the interlocking of stands of *Cardamine amara* with those of *Caltha palustris*, *Geum rivale* and *Carex remota* can be observed. On such a relatively small area, a clear delineation of the different associations is difficult; but it can be stated that the streamlets with running water are settled by *Cardamine amara* and the seeping water area more by *Caltha palustris*, *Geum rivale* and *Carex remota*. A strong relation between large bittercress stands and transition stages between communities of the Montio-Cardaminetalia to those of the Molinietalia, including the alliances Filipendulion, (Filipendulo-Petasition), and Calthion is clearly visible.

Table 1: Community of Large Bittercress Cardaminetum amarae (1-6) and Carici remotae-Calthetum palustris Coldea (1972) 1978 (= Syn. Carici remotae-Cardaminetum amarae Dihoru 1964).

	Number of sample	1	2	3	4	5	6		7	8	9
	Covering degree %	60	70	75	60	55	50		70	90	85
								K			
Mo-Card	***Cardamine amara***	**3**	**4**	**3**	**3**	**3**	**1**	V	.	.	.
C-Mo, Al inc	*Chrysosplenium alter.*	2	1	2	1	2	3	V	.	.	.
Al inc. T. m.	*Glecoma hederacea*	1	.	1	.	1	1	V			
Al inc.	*Scrophularia umbrosa*	+	.	.	.	.	+	II	.	.	.
Ad.	*Doronicum austriacum*	+	.	+	1	.	.	III	.	.	.
Fagion	*Lunaria rediviva*	1	+	+	.	+	+	IV	.	.	.
Fi, Al inc, Fa	*Impatiens noli-tangere*	.	.	+	+	.	+	III	.	.	.
Se flu, Al-Pa	*Myosoton aquaticum*	.	.	1	.	.	.	I	.	.	.
Mo	*Geum rivale*	.	.	.	1	.	.	I	+	2	.
Ca	***Caltha palustris***	.	.	.	1	.	.	I	+	**2**	**3**

Table 1 (continued): Community of Large Bittercress Cardaminetum amarae (1-6) and Carici remotae-Calthetum palustris Coldea (1972) 1978 (= Syn. Carici remotae-Cardaminetum amarae Dihoru 1964).

	Number of sample	1	2	3	4	5	6		7	8	9
	Covering degree %	60	70	75	60	55	50		70	90	85
								K			
Fa-alia	*Fagus sylv. (regen)*	.	.	.	.	+	.	I	.	.	.
x	*Deschampsia caespit.*	.	.	.	.	+	.	I	4	1	2
x	*Athyrium filix-femina*	.	.	.	.	+	.	I	+	+	.
Ae-ion	*Chaerophyllum arom.*	.	.	.	.	.	+	I	+	+	.
Ru-ion alp	*Veratrum album*	.	.	.	.	.	.	–	1	1	.
Mo	*Angelica sylvestris*	.	.	.	.	.	.	–	+	+	+
Ad	*Rumex alpestris (arif.)*	.	.	.	.	.	.	–	+	.	+
Fi-ion	*Filipendula ulmaria*	.	.	.	.	.	.	–	+	3	1
C-Mo,	*Carex remota*	.	.	.	.	.	.	.	.	1	2
Ca, Al inc	*Cirsium rivulare*							–	+	+	.
Art, Ru-ion alp	*Urtica dioica*	.	.	.	.	.	.	–	+	+	.
Mag, Ae-ion	*Ranunculus repens*	.	.	.	.	.	.	–	.	+	.
Arr, Ae-ion, Art	*Rumex obtusifolius*	.	.	.	.	.	.	–	.	+	.
	Sphagnum sp.	.	.	.	.	.	.	–	.	.	1

Localisation of samples: between 1,137-1,319 m a.s.l.; altitude 1,319 m a.s.l., N 45°08’828”, E 22°04’333”; 9: N 45°08’780”, E 22°05’385”. All the other samples are situated between these given altitudes and geographical coordinates.
Abbreviations for the phytocoenological units included in the above table:
Ad = Adenostyletalia, Ae-ion = Aegopodion, Al inc = Alnion incanae, Al-Pa = Alno-Padion, Arr = Arrhenateretalia, Art = Artemisietea, C-Mo = Cardamino-Montion, Ca = Calthion, Fa = Fagetalia, Fi = Filipendulion (Filipendulo-Petasition), Mag = Magnocaricion, Mo = Molinietalia, Mo-Card = Montio-Cardaminetea, Ru-ion = Rumicion alpinae, Se-flu = Senecion fluviatilis, T.m. = Trifolion medii, x = in different groups of classes.

Only in the seepage area on the border of the forest, an interlocking with other species of small, cold water courses, spring and seepage areas can be observed. Apart from the interlocking with phytocoenoses characteristics for wet tall herbaceous vegetation of the alliances Filipendulion (Filipendulo-Petasition), Calthion (order Molinietalia), and the order Adenostyletalia, initial stadia of bogs with *Sphagnum* species and of wet meadows edified by *Deschampsia caespitosa* can be observed.

The studied seepage area (Figs. 2 and 3) outside the forest is mainly composed by a tall herbaceous fringe on the upper part of the slope edified mainly by *Filipendula ulmaria* (1), followed by *Caltha palustris* (2), *Geum rivale* with *Carex remota* (3), *Geum rivale* with *Caltha palustris* (4), all together being bordered on both sides by a small streamlet dominated by *Cardamine amara*. It can be stated that these vegetation patches take part in three different phytocoenological units, i.e. Filipenduletum ulmariae W. Koch 1926, Carici remotae-Calthetum palustris Coldea (1972), 1978 and Cardaminetum amarae (Rübel 1912), Br.-Bl. 1926. The first of these associations is included in the habitat type: 6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels and the other two associations in the habitat type 3220, Alpine rivers and the herbaceous vegetation along banks.

Seeing the common bittercress (*Cardamine amara*) in strong relation with the habitat conditions, of the other phytocoenoses units included in the habitat type 3220, and as well the strong interlocking between the above discussed spring and streamlet phytocoenoses, the inclusion of the higher montane large bittercress phytoconoses with their stenotop characteristics in this habitat type of community interest is justified.

Figure 2: Large seeping streamlet area on the border of a beech forest in the Nergăniţa Spring area (autumnal aspect).

The occurrence of the large bittercress in the Semenic Mountains area in the large network of springs and spring streamlets is an indicator for the high quality of the beech forest area of the “Nature Reserve Semenic Mountains and springs of Nera River”, as it is a typical habitat type for areas with clean waters in the frame of the beech forest area with a same high quality and biodiversity.

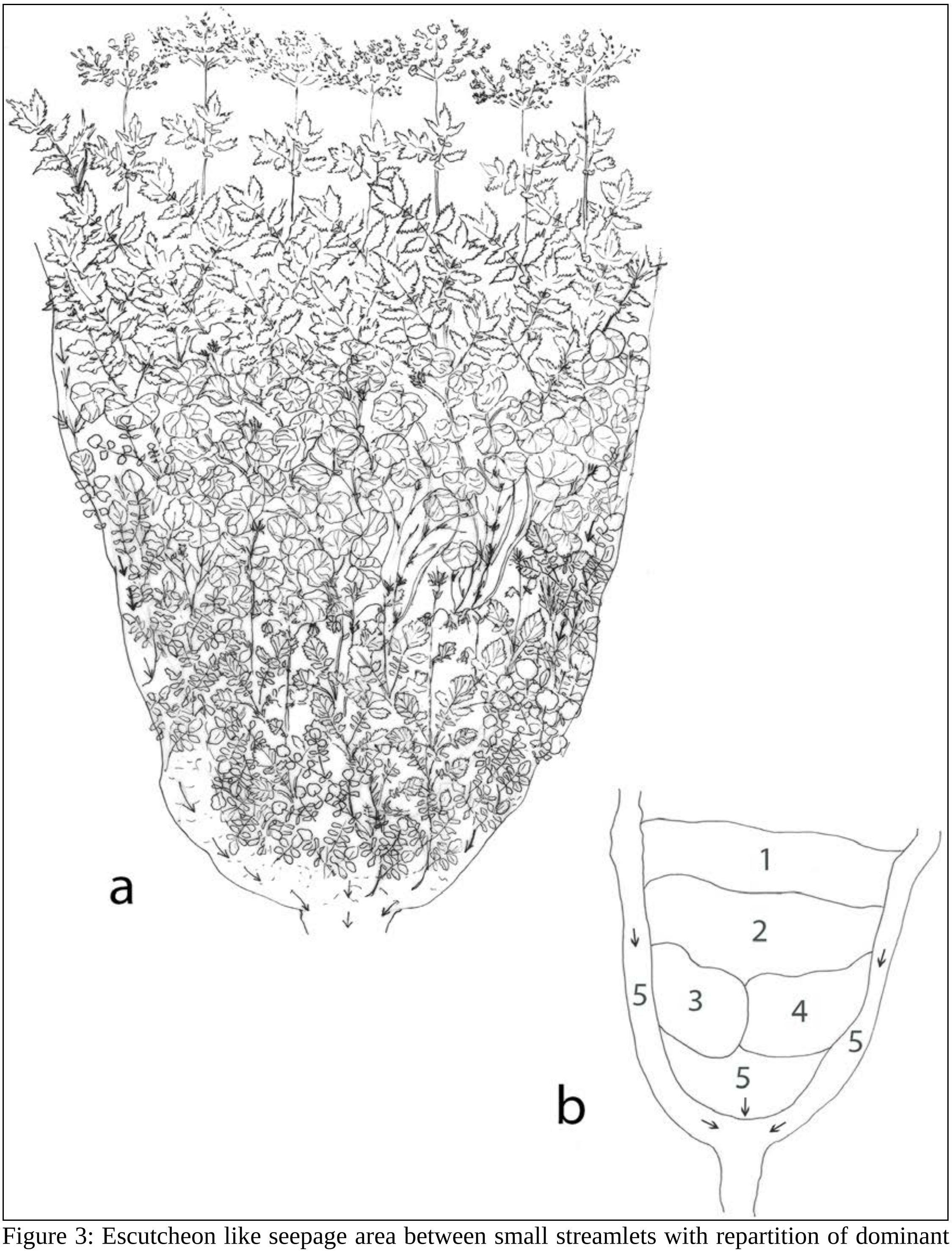

Figure 3: Escutcheon like seepage area between small streamlets with repartition of dominant species **a**: seeping water area with the structure of the vegetation cover, **b**: repartition of the dominant species: 1 *Filipendula ulmaria*, 2 *Caltha palustris*, 3 *Geum rivale* and *Carex remota*, 4 *Geum rivale* and *Caltha palustris*, 5 *Cardamine amara* on the border and in the streamlets.

CONCLUSIONS

The vegetation of the spring area of the large bittercress (*Cardamine amara* L.) in the sub-basin of Nergăniţa, a headwater stream of the Nera River, is an example for spring and spring streamlet habitats with a stenotopic character and a stable structure. The habitat type and the communities and their species composition are in strong relation with the ecological limiting factors such are the more or less constant water temperatures during the vegetation period, and the shadow condition under the canopy of the beech forest crowns. *Cardamine amara*, the dominant species, is well adapted to these cold and clear running waters of the spring streamlets. The large bittercress stands at the altitude of 1,100-1,350 m of the Semenic Mountains and have an intermediary position between those of higher montane levels and those of the lower montane levels as well as the lower hill areas and plains and have their particularity due to the mentioned site conditions.

The seepage area on the border of the forest are remarkable for their complexity with the interlocking of different phytocoenoses, but all being well adapted to the spring streamlets conditions and also have a stable character. The shore from hygrophilous tall herbaceous fringe habitats to phytocoenoses edified mostly by *Caltha palustris* with *Geum rivale* and *Carex remota* and at least to some small patches of bogs, demonstrates the dynamic character of the area with stable ecological conditions, i.e. the natural hydrological regime of the streamlets and the good state of the forest. For their conservation and sustainability the appropriate conservation management of the forest with its streamlets, with all micro and macro-habitats is of high priority.

ACKNOWLEDGEMENTS

Many thanks to Ovidiu Adascăliţei from WWF Romania, branch office Reşiţa for his valuable help and assistance during field activities in the National Parks Semenic-Cheile Caraşului/Semenic Mountains – Caraş gorge and Cheile Nerei-Beuşniţa/Gorge of Nera-Beuşniţa.

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ASSOCIATED FAUNA TO *EICHHORNIA CRASSIPES* IN A CONSTRUCTED WETLAND FOR AQUACULTURE EFFLUENT TREATMENT

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DOI: 10.1515/trser-2017-0003

KEYWORDS: floating macrophytes, zooplankton, aquaculture effluents, macrofauna.

ABSTRACT

Water, sediment and associated fauna were studied in a water hyacinth (*Eichhornia crassipes*) stand of a constructed wetland, used for aquaculture effluent treatment in SE Brazil, in February-April (summer/rainy season) and July-September (winter/dry season). The hydrological regime and decomposition processes had strong impact on the wetland water quality and on the associated fauna composition. Protozoa and Rotifera were at high densities, mainly in the dry season. *Vorticella* sp. was the dominant species in both seasons. Zooplankton richness, evenness and diversity were high during both seasons, with higher levels during the rainy season. Protozoa diversity and evenness were higher in the dry season when the water volume was lower. Maximum plant residence time in this wetland should be about 60 days.

RESUMEN: Fauna asociada a *Eichhornia crassipes* en un humedal artificial para tratamiento de efluentes de acuacultura.

Agua, sedimento y fauna asociada fueron muestreados entre las *Eichhornia crassipes* de un humedal artificial en el SE de Brasil usado para tratar efluentes de acuacultura, durante febrero-abril (verano/estación lluviosa) y julio-septiembre (invierno/estación seca). El régimen hidrológico y los procesos de descomposición tuvieron un fuerte impacto sobre la calidad de agua dentro del humedal y sobre la composición de la fauna asociada. Protozoa y Rotífera presentaron alta densidad, especialmente durante la estación seca. *Vorticella* sp. fue la única especie dominante en ambas estaciones. En ambos períodos la riqueza, uniformidad y diversidad del zooplancton fueron altas, siendo mayores en la estación lluviosa. La diversidad y uniformidad de Protozoa fueron mayores en la estación seca, cuando el volumen de agua era menor. El tiempo máximo de residencia de las plantas debería ser de unos 60 días.

REZUMAT: Fauna asociată speciei *Eichhornia crassipes* într-o zonă umedă artificială pentru tratarea efluenților din acvacultură.

S-au analizat apa, sedimentul și fauna asociată dintr-o parcelă de *Eichhornia crassipes* dintr-o zonă umedă construită pentru tratarea efluenților din acvacultură în SE Braziliei, în perioadele februarie-aprilie (vară/sezon ploios) și iulie-septembrie (iarnă/sezon secetos). Regimul hidrologic și procesele de descompunere au avut un impact puternic asupra calității apei din zona umedă precum și asupra compoziției faunistice asociate. Protozoarele și rotiferele au prezentat densități mari, în special pe timpul sezonului secetos. *Vorticella* sp. a fost singura specie dominantă din ambele sezoane. Abundența, distribuția și diversitatea zooplanctonului au fost mari în ambele sezoane, dar cu valori superioare în sezonul ploilor. Diversitatea protozoarelor și distribuția lor au fost mai ridicate în sezonul secetos, când volumul de apă a fost mai scăzut. Timpul maxim de ședere al plantelor în această zonă umedă ar trebui să fie de circa 60 zile.

INTRODUCTION

Macrophytes and riverine vegetation perform different functions in the aquatic ecosystem, such as increasing habitat heterogeneity, providing food and shelter for many organisms and creating patches under specific physicochemical conditions (Curtean-Bănăduc et al., 2014; Gutierrez and Mayora, 2016). In turn they are affected by the growth rate, abundance and activity of those associated organisms (O'Hare et al., 2012). The organic matter retained among their roots consists of particles that can be utilized as food by the macrofauna associated with the plants, promoting a rapid circulation through the trophic web. Different species of macrophytes have been characterized by dissimilar physiological and chemical composition, which result in the release of different types of substrates that may affect the availability of ecological niches for different associated communities (Zeng et al., 2012).

Eichhornia crassipes, commonly known as water hyacinth, is an aquatic plant native to the Amazon Basin, with a high potential to retain inorganic and organic material in its biomass. Outside its native range it is often considered a problematic invasive species (Villamagna and Murphy, 2009), so that serious measures have been taken to impair its propagation, as well as to find a practical use for its large available biomass. In recent years it has received much attention due to its potential benefits for biogas production, fertilizer, water purification, as well as animal and aqua feed (Malik, 2007). *E. crassipes* has well-develop adventitious roots, lateral roots, and epidermal hairs, which together with its stems, leaves and stolons constitute a complex structure which offers suitable habitat or shelter for numerous organisms (Montiel-Martínez et al., 2015).

Zooplankton is a key component of freshwater ecosystems (Onciu et al., 1999) and frequently uses macrophytes as a refuge from vertebrate predators or as a substrate where to dwell and feed (Gutierrez and Mayora, 2016). Some species of the major secondary producers (Rotifera, Cladocera and Insecta larvae) are commonly found in pelagic and vegetation areas, whereas others are found in or around the vicinity of vegetation stands (Kouamé et al., 2011). Aquatic plants can be used not only as a place to grow in but also as a refuge, since they reduce mortality risk to zooplankton capable of detecting chemical cues from potential predators (Montiel-Martínez et al., 2015). In addition, macrophytes are usually covered by epiphytes that are grazed upon by several invertebrates whose diversity, abundance and distribution pattern are influenced by macrophytes (Kouamé et al., 2011).

Constructed wetlands are artificial ecosystems based on macrophytes that are widely used to treat effluents of different types. The community structure and hence the ecological functioning of these systems varies with climatic conditions. The current article investigates *Eichhornia crassipes* development, structure of its associated fauna and environmental conditions during the rainy and dry seasons, in the *E. crassipes* section of a constructed wetland used to treat effluents of an aquaculture farm.

MATERIAL AND METHODS

Study area and sampling site

The study was carried out in the constructed wetland for aquaculture effluents treatment in a southeastern Brazil farm (21º14'S and 48º18'W) (Fig. 1). Monthly means of meteorological conditions during the summer/rainy season (February to April) were – air temperature: 24 ± 1.2°C, water temperature: 24 ± 3.3°C and 85 ± 2 mm rainfall; during the winter/dry season (July to September) the monthly means were 22 ± 2.3°C, 23 ± 3°C and 25 ± 23 mm. The effluent entering the wetland originated from six earthen fishponds with areas varying between 1,822 and 8,067 m². Some fishponds received water from other smaller earthen ponds further up the watershed. The wetland also receives effluent (swine manure) from an anaerobic sludge blanket reactors (UASB) installed in series, with volumes ranging between 50 and 908 l, which discharged the material about once a week when reactors are switched on. During the rainy period the wetland also receives surface runoff through a channel. The wetland was 71 m long, with a total area of 96.6 m^2, and lined with a shallow clay bottom. It was planted with three native macrophyte species, *Cyperus giganteus* and *Typha domingensis* (34 m^2) close to the inlet water to restrain the strong water flow, mainly in the rainy season, followed by a *Eichhornia crassipes* (32 m^2) stand where the associated fauna and ecological conditions were evaluated. Immediately after plant transplantation, the wetland was filled to a depth of approximately 0.30 m. The plants were installed twice, once for the summer/rainy season (February to April) sampling and once for the winter/dry season (July to September) sampling, and were completely removed between both periods.

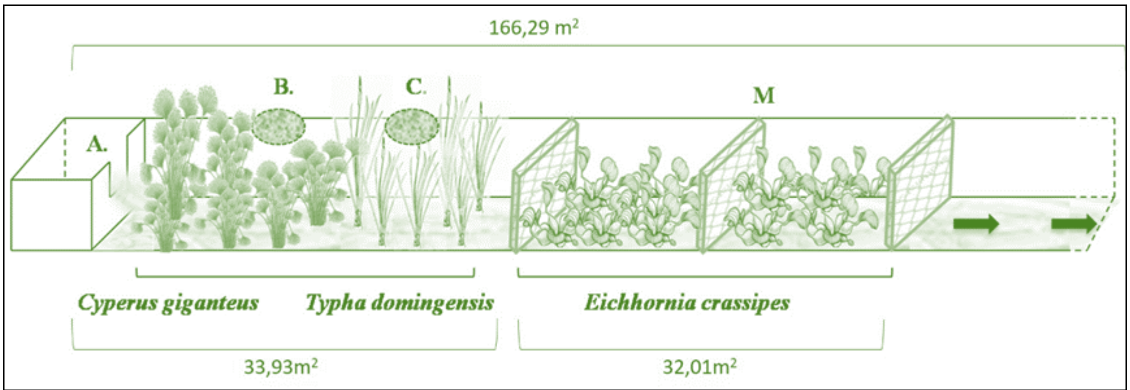

Figure 1: Diagram of the wetland system studied; A = effluents from the aquaculture farm, B = effluents from the biodigestor, C = rainwater input, M = sampling site, arrows = direction of water flow.

E. crassipes biological data

The growth of *E. crassipes* biomass was determined every fortnight during each sampling period, measuring their foliar length and width and rhizome length. Measurements were taken on the same 12 marked plants randomly chosen at the beginning of the experiment. Dry and wet masses were recorded at the end of each growth period. The plants were collected using a 0.18 m^2 quadrant, dried at 60ºC until constant weight, and weighted. Plant nutrients composition was analysed according to Bataglia et al. (1983).

Associated fauna

Samples of associated fauna were retrieved every fortnight during both periods of aquatic plant growth. All plants collected with the 0.18 m^2 floating quadrant, were washed in the laboratory with distilled water using 200 µm, 58 µm and 25 µm sieves. The collected fauna was preserved in 4% formalin, allowed to settle and the total collected volume measured, and stored in amber glass jars. Rotifera and Protozoa samples were analyzed with a Sedgewick-Rafter counting cell and examined under 100X magnification. Cladocera, Copepoda, Insecta, Mollusca, Platyhelminthe, Nematoda, Ostracoda and Harpacticoida were counted in a reticulated chamber. Protozoa were grouped into two taxonomic categories: Testate amoebae (Amoebozoa and Rhizaria) and Ciliates (Ciliophora) (Adl et al., 2005). Insecta were identified at order level and Nematoda, Mollusca and Platyhelminthes at phylum level.

Water and sediment

Surface water and sediment samples were collected every fortnight inside the *E. crassipes* stand. Water was sampled with a one l Van Dorn bottle and transported in refrigerated polyethylene bottles to the laboratory. Water temperature, turbidity, pH, dissolved oxygen (DO) and conductivity were measured in situ with a Horiba U-10 multi-sensor. Total phosphorus and nitrogen compounds were quantified spectrophotometrically, following Golterman et al. (1978) and Koroleff (1976). Chlorophyll-*a* was extracted with alcohol 90% and quantified at 663 nm and 750 nm (Nusch, 1980). Total suspended solids (TSS) and total dissolved solids (TDS) were determined according to Boyd and Tucker (1992). Water samples for microbiological analysis, using the multiple-tube methods, were collected in sterilized 500-ml flasks and taken to the laboratory in an isothermal container. The material used in the microbiological analysis (thermotolerant coliforms) was sterilized prior to use (APHA, 1995).

Vertically mixed sediment samples were retrieved with a four cm diameter PVC core up to approximately 10 cm deep. Sediments were air dried, gently disaggregated and dried in a convection oven at 70°C until completely dry. Determinations of organic matter (OM), Ca, Mg, P, K, N, Fe, Zn and pH were performed according to methods described by Raij et al. (2001). Analyses were performed immediately after sampling or when necessary samples were duly stored under refrigeration.

Data analysis

All data underwent one-way analysis of variance (ANOVA) with the Statistica 10 package, to test differences between seasons (Statsoft, 2011). Differences were considered significant at $p < 0.05$. All results were expressed as means ± SD (Standard Deviation). Pearson correlation coefficients were calculated among environmental variables. Associated fauna diversity was calculated with the Shannon-Wiener (H') index (Pielou, 1975). Richness (S) was calculated as the total number of species present and evenness or equitability (E) was determined as H/H max, where H is the Shannon-Wiener index and H max = ln S. Species dominance (D) and abundance (A) were analyzed for organisms associated to macrophyte. Species were considered dominant when the density was higher than 50% of the total number of specimens present in the sample; they were abundant when the number of specimens was higher than the mean density of all occurring species (Lobo and Leighton, 1986).

Table 1: Water quality in the constructed wetland: Mean ± SD in the rainy and dry seasons * and list of variables significantly correlated with each variable **.

Variables	Rainy season	Dry season	Variable positively correlated with	Variable negatively correlated with
temperature (°C)	25.4 ± 1.6^{a}	20.8 ± 1.8^{b}	TSS	cond, DO, NO_3, TDS
pH	6.7 ± 0.1^{a}	6.8 ± 0.5^{a}	NO_3	PO_4, Tot P
Conductivity ($\mu S. cm^{-1}$)	93 ± 19^{a}	105 ± 15^{a}		tem
turbidity (NTU)	21.6 ± 15.1^{a}	20.2 ± 5.6^{a}	colif, chlor	
alkalinity ($mg. l^{-1}$)	54 ± 6.0^{a}	50 ± 3.7^{a}		
DO ($mg. l^{-1}$)	2.9 ± 1.3^{b}	5.3 ± 1.9^{a}	NO_3	tem
TAN ($\mu g. l^{-1}$)	550 ± 167^{a}	818 ± 615^{a}	NO_2, PO_4, Tot P	

Table 1 (continued): Water quality in the constructed wetland: Mean ± SD in the rainy and dry seasons [*] and list of variables significantly correlated with each variable [**].

Variables	Rainy season	Dry season	Variable positively correlated with	Variable negatively correlated with
NO_2 (µg. l^{-1})	11.5 ± 6.7^a	13.9 ± 6.5^a	TAN, Tot P	
NO_3 (µg. l^{-1})	37.8 ± 31^b	150 ± 95^a	pH, DO, TDS	tem
PO_4 (µg. l^{-1})	19.8 ± 9.0^a	48 ± 68^a	TAN, Tot P	pH
Total P (µg. l^{-1})	38.6 ± 19^a	86 ± 125^a	TAN, NO_2, PO_4	pH
BOD (mg. l^{-1})	57 ± 54^a	83 ± 47^a	TDS	
TSS (mg. l^{-1})	12.6 ± 4.1^a	8.4 ± 2.9^a	tem, colif, chlor	TDS
TDS (mg. l^{-1})	180 ± 57^a	364 ± 188^a	NO_3, BOD	tem, TSS
coliforms (MPN)	19.512 ± 41.644^a	542 ± 462^a	turb, TSS, chlor	
chlorophyll-*a* (µg. l^{-1})	80 ± 76^a	39 ± 22^a	turb, TSS, colif	

[*] In each row, means followed by the same letter do not significantly differ ($p < 0.05$).
[**] Pearson Correlation at least $p < 0.05$.

RESULTS

The water quality parameters (Tab. 1) showed significant differences between seasons only for temperature, dissolved oxygen and nitrate. Water temperature was higher in the rainy summer, while oxygen and nitrate were higher in the dry winter. There were significant positive correlations among TSS, coliforms, chlorophyll-*a* and turbidity, which indicates that phytoplankton and bacteria formed an important portion of the particles flowing in the wetland water. There were significant positive correlations among TAN, nitrite, phosphate and total phosphorus, which indicates that decomposition processes strongly affected water quality in the wetland. The lack of correlation among oxygen, pH and chlorophyll-*a* indicates that photosynthesis by phytoplankton had little effect on the water quality flowing through the wetland, at least as compared with the strong effect of decomposition.

In the sediment, significant differences between seasons were observed for organic matter, Ca and N, which were higher during in the dry season, and for K, which was higher during the rainy season (Tab. 2). The pH of the sediment was acidic and the highest nutrient concentration was observed for Ca in the dry season (Tab. 2).

E. crassipes reached 50-55 cm total length (rizoma + aerial plant) in 60 days of growth, in either the rainy or in the dry season (Fig. 2). Nutrients in the aquatic plants biomass were much higher than those observed in the sediment, indicating incorporation of these nutrients in their growth. Nutrients in the plant biomass were higher during the dry season, except for Mg, Fe and Zn. The highest nutrient concentrations in the aquatic plants were of K. The opposite occurred with K in the sediment, which was below 0.1 $g.m^{-2}$ (Tab. 2). Plants wet biomass was higher during the dry season, whereas plants dry biomass was similar in both seasons (Tab. 2).

Table 2: Mean and SD concentrations * of variables measured in sediment and *E. crassipes* plants during the rainy and dry seasons.

Variables	Rainy season	Dry season
Sediment (g. dm^{-3})		
N	0.64 ± 0.19^{b}	1.08 ± 0.33^{a}
P	0.08 ± 0.03^{a}	0.09 ± 0.01^{a}
K	0.06 ± 0.001^{a}	0.05 ± 0.002^{b}
Ca	1.81 ± 1.19^{b}	2.20 ± 0.51^{a}
Mg	0.24 ± 0.10^{a}	0.24 ± 0.04^{a}
Fe	0.11 ± 0.01^{a}	0.12 ± 0.02^{a}
Zn	0.003 ± 0.002^{a}	0.006 ± 0.003^{a}
Organic Matter	15.0 ± 3.9^{b}	29.8 ± 9.4^{a}
pH	5.2 ± 0.5^{a}	5.4 ± 0.2^{a}
Plant (g. m^{-2})		
N	8.3 ± 4.9^{b}	10.4 ± 6.2^{a}
P	1.0 ± 0.7^{b}	1.5 ± 1.1^{a}
K	24.0 ± 18.8^{b}	30.6 ± 18.8^{a}
Ca	4.5 ± 2.6^{b}	5.0 ± 2.7^{a}
Mg	1.5 ± 0.8^{a}	1.7 ± 0.7^{a}
Fe	3.9 ± 2.4^{a}	1.6 ± 0.9^{b}
Zn	0.05 ± 0.03^{a}	0.05 ± 0.03^{a}
Wet mass	$7{,}698 \pm 4{,}880^{b}$	$9{,}875 \pm 5{,}709^{a}$
Dry mass	339 ± 185^{a}	368 ± 184^{a}

* In each row, means followed by the same letter do not significantly differ ($p < 0.05$)

The *E. crassipes* associated zooplankton community comprised 51 taxa, 43 Rotifera, three Cladocera, four Copepoda, and one Ostracoda. Insecta consisted of six orders and Protozoa comprised seven genera. The phyla Nematoda, Mollusca and Platyhelminthes had low contribution. Diversity and species abundance were higher in the rainy season (Tab. 3) due to the contributions of allochthonous material from the fish ponds. Total density was 33% lower in the dry compared with the rainy season. The most abundant organisms were Protozoa, among which Ciliophora comprised over two thirds of the total organisms collected, followed by Rotifera with 22% of the total organisms in the rainy season and 14% in the dry season (Fig. 3). *Vorticella* sp. was the only dominant species in both seasons. *Arcella* sp. (Protozoa), *Proales doliares* and *Lecane bulla* (Rotifera) were abundant in both seasons (Tab. 4). During the dry season only Rotifera and Protozoa occurred in the *E. crassipes* associated fauna, with dominance of *Vorticella* sp. Species of Cladocera were abundant or present during the rainy season, albeit absent in the dry season. The opposite was observed for the adult and nauplii Copepoda *Argyrodiaptomus furcatus*. The associated fauna tended to have high zooplankton species richness (above 46 species), evenness (above 0.66) and diversity (Shannon-Wiener index with 3.45 and 2.44 nats ind^{-1}) during the rainy and the dry seasons (Tab. 3).

Table 3: Volume of associated fauna washed out from the *E. crassipes* growing in a 0.18 m area (range), and average density *, species richness, evenness and Shanon-Wiener diversity (H') index in each season.

	Rainy season	Dry season
Associated fauna volume (ml)	1,440-1,820	1,160-1,600
Zooplankton total	**1,107,500**	**413,500**
Cladocera (ind. m^{-2})	109,800	0
Copepoda (ind. m^{-2})	24,000	800
Ostracoda (ind. m^{-2})	9,700	1,500
Rotifera (ind. m^{-2})	964,000	411,200
Richness	51	46
Evenness	0.88	0.66
Diversity (H')	3.45	2.44
Protozoa total (ind. m^{-2})	**3,287,000**	**2,558,000**
Amoebozoa (ind. m^{-2})	152,000	120,000
Rhizaria (ind. m^{-2})	72,000	53,000
Ciliophora (ind. m^{-2})	3,063,000	2,385,000
Richness	8	7
Evenness	0.12	0.16
Diversity (H')	0.46	0.60
Insecta total	**4,654**	**90**
Collembola (ind. m^{-2})	3	0
Coleoptera (ind. m^{-2})	57	8
Diptera (ind. m^{-2})	4,500	25
Hemiptera (ind. m^{-2})	6	30
Neuroptera (ind. m^{-2})	0	1
Odonata (ind. m^{-2})	88	26
Richness	6	5
Evenness	0.37	0.25
Diversity (H')	1.42	0.92
Others total	**3,936**	**3,550**
Nematoda (ind. m^{-2})	3,600	2,300
Mollusca (ind. m^{-2})	36	850
Platyhelminthes (ind. m^{-2})	300	400
Richness	3	3
Evenness	0.09	0.24
Diversity (H')	0.36	0.89

* ind. m^{-2} of *E. crassipes*.

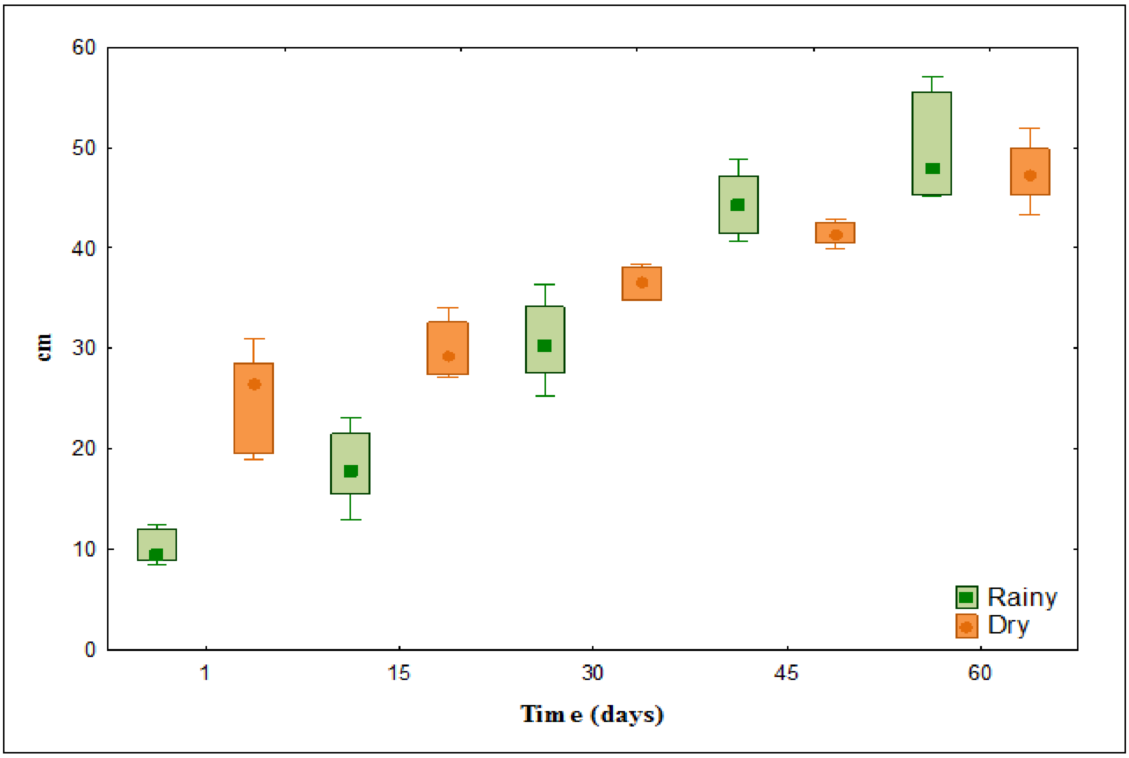

Figure 2: Total length (rizoma + aerial plant) growth of Eichhornia crassipes during the rainy and dry seasons. Measurements are mean ± SD of 12 plants.

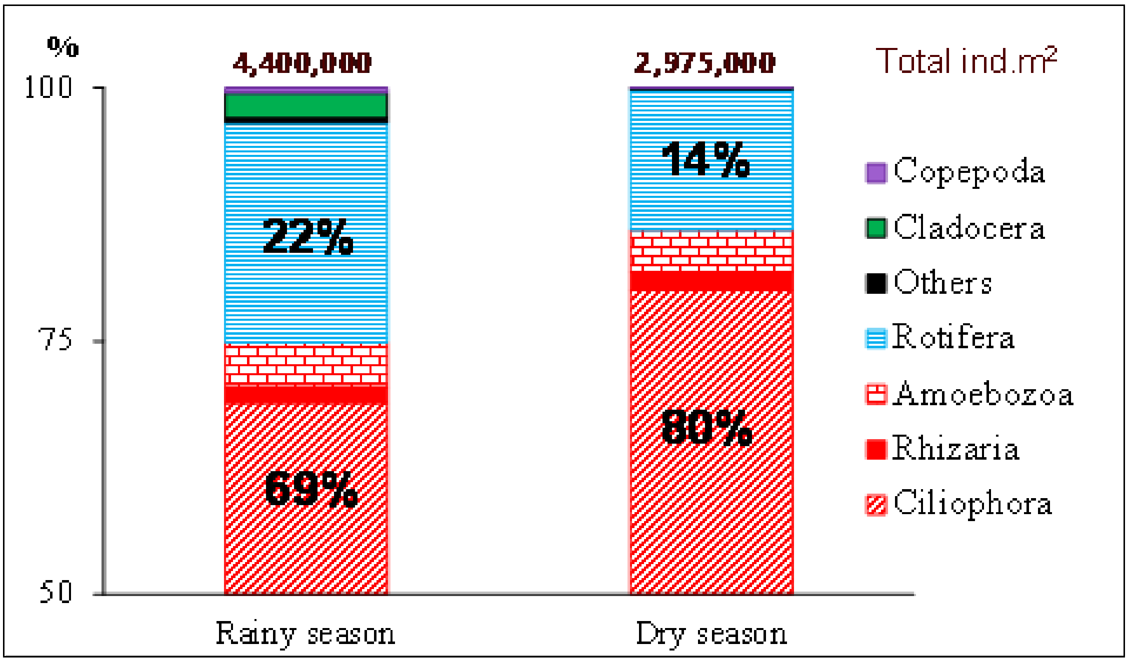

Figure 3: Relative abundance of *E. crassipes* associated fauna and average total density recorded in the rainy and dry seasons. Note that the x-axis starts at 50%. Others = Insecta, Ostracoda, Nematoda, Mollusca and Plathyelminthes.

Table 4: Frequency of occurrence * of associated fauna to *E. crassipes* in the rainy and dry seasons.

Taxa	**Rainy season**	**Dry season**
Cladocera		
Alona guttata (Sars, 1862)	A	–
Ilyocryptus spinifer (Herrick, 1882)	A	–
Diaphanosoma birgei (Korinek, 1981)	+	–
Copepoda		
Thermocyclops decipiens (Kiefer, 1929)	+	+
Thermocyclops minutus (Lowndes, 1934)	+	+
nauplii	A	+
Argyrodiaptomus furcatus (Sars, 1901)	–	+
nauplii	–	+
Harpacticoida	+	+
Ostracoda	+	+
Rotifera		
Ascomorpha ovalis (Bergendal, 1892)	–	A
Ascomorpha saltans (Bartsch, 1870)	+	+
Asplanchnopus sp. (Guerne, 1888)	+	A
Brachionus falcatus (Zacharias, 1898)	+	–
Brachionus calyciflorus (Pallas, 1766)	–	+
Cephalodella misgurnus (Wulfert, 1937)	+	+
Cephalodella gibba (Ehrenberg, 1830)	+	A
Collotheca mutabilis (Hudson, 1885)	+	+
Collotheca ornata (Ehrenberg, 1832)	+	+
Colurella obtusa (Gosse, 1886)	A	+
Colurella uncinata (Müller, 1773)	A	+
Conochilus sp. (Ehrenberg, 1834)	–	+
Dipleuchlanis propatula (Gosse, 1886)	–	+
Euchlanis dilatata (Hauer, 1930)	+	A
Epiphanes macrourus (Barrois and Daday, 1894)	+	+
Filinia opoliensis (Zacharias, 1898)	+	–
Heterolepadella heterostyla (Murray, 1914)	+	+
Keratella cochlearis (Gosse, 1851)	–	+
Keratella tropica (Apstein, 1907)	–	+
Lecane aculeata (Jakubski, 1912)	+	+
Lecane bulla (Grosse, 1851)	A	A
Lecane calcaria (Harring and Myers, 1926)	–	+
Lecane cornuta (Müller, 1786)	+	+
Lecane curvicornes (Murray, 1913)	+	+
Lecane furcata (Murray, 1913)	+	+
Lecane hornemanni (Ehrenberg, 1834)	+	+
Lecane inermis (Bryce, 1892)	–	+
Lecane ludwigii (Eckstein, 1883)	+	+
Lecane lunaris (Ehrenberg, 1832)	A	+

Table 4 (continued): Frequency of occurrence * of associated fauna to *E. crassipes* in the rainy and dry seasons.

Taxa	**Rainy season**	**Dry season**
Lecane monostyla (Daday, 1897)	+	+
Lecane proiecta (Hauer, 1956)	+	+
Lecane signifera (Jennings, 1896)	+	+
Lepadella sp. (Bory de St. Vincent, 1826)	+	+
Philodina sp. (Ehrenberg, 1830)	+	+
Proalinopsis caudatus (Collins, 1873)	+	A
Proales doliaris (Rousselet, 1895)	A	A
Proales globulifera (Hauer, 1921)	+	+
Ptygura fucillata (Kellicott, 1889)	–	+
Synchaeta stylata (Wierzejski, 1893)	–	+
Testudinella patina (Hermann, 1783)	+	+
Testudinella sp.	+	+
Trichocerca cavia (Gosse, 1886)	+	+
Trichocerca similis (Wierzejski, 1893)	+	+
Protozoa		
Amoebozoa		
Arcella sp.	A	A
Centropyxis sp.	+	+
Difflugia sp.	+	–
Euplotes sp.	–	+
Rhizaria		
Euglypha sp.	A	+
Ciliophora		
Paramecium sp.	A	+
Vorticella sp.	D	D
Insecta		
Collembola	+	–
Coleoptera	+	+
Diptera	+	+
Hemiptera	+	+
Neuroptera	–	+
Odonata	+	+
Others		
Nematoda	+	+
Mollusca	+	+
Platyhelminthes	+	+

* + = present; – = absent; A = abundant; D = dominant.

DISCUSSION

The water quality in the constructed wetland was very variable during each studied period, so that most of the environmental parameters measured did not show significant differences between the rainy and the dry seasons. The rainy season is during summer and the dry one during winter, which accounts for the water temperature differences between seasons. The significantly higher oxygen and nitrate concentrations in the dry than in the rainy seasons are at least partially accounted for by differences in the hydrological regime during both seasons. The rainy season is also the main fish culture period in the aquaculture farm, so that the constructed wetland received, together with rain and surface runoff, increased amounts of effluents (with organic matter that consumed oxygen). During this period, the water flow and turbulence inside the wetland were strong and the water outflow contained large amounts of particles. Under these conditions nitrification was reduced due to loss of nitrifying bacteria attached to the washed out particles, resulting in the observed reduced nitrate concentration in the water. Reduced nitrification related to washout were already observed in flow-through fish culture systems with high water exchange rates (Diab et al., 1992; Milstein et al., 2001) and even in stagnant fishponds flooded and washed out by heavy monsoon rains (Milstein et al., 2002). Together with this, numerous insects and rather large aquatic organisms that can withstand water turbulence and washout (crustaceans, mollusks, and helminths) were abundantly found in the *E. crassipes* associated fauna. On the contrary, during the dry season less effluents and few surface runoff entered the wetland (less oxygen consumption) so that water flow and turbulence in the constructed wetland were low allowing sedimentation of most particles and reducing particles washout from the system. Under these conditions nitrifying bacteria remained in the wetland, increasing nitrate levels in the water, as well as the small organisms (protozoa and rotifers) that dominated in the *E. crassipes* associated fauna.

In this flow-through system, phytoplankton entering with the effluents encountered an unfavorable environment within the wetland due to macrophytes shadowing and competition for nutrients, and also were rather quickly washed out. Thus, phytoplankton photosynthesis had little effect on the wetland water quality, as indicated by the lack of correlation among oxygen, pH and chlorophyll-*a*. The high loading of organic matter entering with the aquaculture ponds and UASB effluents and particle trapping by the macrophytes should have favored decomposition processes, as indicated by the significant positive correlations among the decomposition products TAN, nitrite and phosphate recorded in the water sampled among the macrophytes. The thermotolerant coliforms get it these effluents should have fostered a detrital food net where tiny in size rotifers, protozoa, and cyclopoid copepod nauplii have a successful competing favored position in this circumstance.

Protozoa, the most abundant organisms in this study, are widespread in wetland rhizospheres where feeding on roots and microorganisms is enhanced (Neori and Agami, 2016). Arcellidae is one of the predominant families, coupled with Difflugiidae and Centropyxidae in the community structures of wetland environments (Lansac-Tôha et al., 2014). High dominance of *Vorticella* sp. during the sampled period shows that the free-living ciliophorans are commonly encountered in fish ponds. However, when fish are stressed by adverse environmental conditions, the ciliophorans become a facultative ectoparasite (Abdel-Baki et al., 2014). According to Mieczan (2007), populations of Protozoa in aquatic environments are directly related to the presence of suspended solids produced by fast life cycle macrophytes, such as *E. crassipes.*

Rhizosphere invertebrates function ecologically as Protozoa in the consumption of exudates, biota, flora and root tissue, by modifying nutrients and influencing plant growth (Neori and Agami, 2016). The continuous growth of the plants until the end of each sampled period provided a large abundance of associated organisms, mainly during the rainy season.

E. crassipes provides an extra habitat for macro- and micro-invertebrates due to its large radicular system available in the water column, which traps particles and is used as both food and substrate (Chowdhary and Sharma, 2013). The observed large diversity, richness and evenness of zooplankton in the *E. crassipes* associated fauna were mainly related to rotifer species. Rotifers predominate in environments with human activities since they reproduce and rapidly adapt themselves to environmental changes (Dahms et al., 2011). The large abundance of rotifer species recorded is related to the large water volumes containing them, which the wetland received from several aquaculture ponds (Sipaúba-Tavares and Dias, 2014).

E. crassipes submerged and areal parts provide appropriate habitat and trophic resources for insects. At least for Diptera and Odonata assemblages, it was reported that the aquatic plants support assemblages of these insects, abundance and richness of which depend on the abundance and distribution of the vegetation (Capello et al., 2013).

The ecological indexes were higher in the rainy season for zooplankton and Insecta as a result of high water flow from the different fish ponds during that period. This occurred because the aquaculture farm has a continuous water flow of which about 60% of the water volume goes to the wetland under analysis. However, the diversity and evenness of Protozoa species were higher during the dry season when the water volume was lower and species stabilized at the *E. crassipes* roots. After 60 days, plants in the wetland had to be removed due to lack of space for their development. Consequently, maximum residence time of the plant in this wetland should be approximately 60 days, with complete regular harvest to maintain the retention and incorporation of water nutrients into the plants biomass.

ACKNOWLEDGEMENTS

The authors would like to thank the Foundation for Research Support of the State of São Paulo (FAPESP) for funding (14/24697-3) and for the scholarship to the last author (14/08186-9). Thanks are also due to Brazilian Council for Scientific and Technological Development (CNPq) and to Carbonin E. R. for counting insect organisms.

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TOXICITY EFFECTS OF CADMIUM IN GRASS CARP (*CTENOPHARYNGODON IDELLA*) AND BIG HEAD CARP (*HYPOPHTHALMICHTHYS NOBILIS*)

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DOI: 10.1515/trser-2017-0004

KEYWORDS: Fish, Cadmium Chloride, Toxicity, 96 h LC_{50}.

ABSTRACT

Heavy metals can threaten ecosystem health and of food security. The purpose of percent study was evaluating the sensitivity of grass carp (*Ctenopharyngodon idella*) and Big head carp (*Hypophthalmichthys nobilis*) exposed to cadmium Chloride. To this end, fishes were exposed different concentrations of cadmium in range of cadmium chloride (0, 0.2, 1, 2, 6, 10 and 15 ml/l). The mortality of treatments was calculated at intervals of 24, 48, 72, 96 hours. Analysis of the data showed the 96 h LC_{50} of cadmium chloride for grass carp was 4.164 ml/l and for Big head carp was 5.590 ml/l. The results of this study showed that Cadmium is highly toxic for freshwater species.

RESUMEN: Evaluar la toxicidad del cadmio en la carpa de hierba (*Ctenopharyngodon idella*) y en la carpa de cabeza grande (*Hypophthalmichthys nobilis*).

Los metales pesados pueden amenazar la salud de los ecosistemas y la seguridad alimentaria. El propósito del estudio porcentual fue evaluar la sensibilidad de la carpa herbívora (*Ctenopharyngodon idella*) y la carpa cabezona (*Hypophthalmichthys nobilis*) frente al cadmio. Con este fin, los peces fueron expuestos a diferentes concentraciones de cadmio en un rango de 0, 0,2, 1, 2, 6, 10 y 15 mg/l de cloruro de cadmio. La mortalidad en los tratamientos se calculó a intervalos de 24, 48, 72 y 96 horas. El análisis de los datos mostró que la LC50 de Cadmio (cloruro de cadmio) para la carpa herbívora a las 96 h fue de 4.164 mg/l y para la carpa cabezona de 5.590 mg/l. Los resultados de este estudio mostraron que el cadmio es altamente tóxico para las especies de agua dulce.

REZUMAT: Evaluarea toxicității cadmiului la amur (*Ctenopharyngodon idella*) și la novac (*Hypophthalmichthys nobilis*).

Metalele grele pot pune în pericol sănătatea mediului și securitatea alimentară. Prezentul studiu a avut ca obiectiv evaluarea sensibilității amurului (*Ctenopharyngodon idella*) și novacului (*Hypophthalmichthys nobilis*) la cadmiu. În acest scop, peștii au fost expuși la diferite concentrații de cadmiu sub formă de clorură (0, 0,2, 1, 2, 6, 10 și 15 ml/l). Mortalitatea indusă de administrări a fost calculată la intervale de 24, 48, 72 și 96 ore. Analiza datelor arată că LC50 a cadmiului (clorură de cadmiu) la amur după 96 ore a fost 4/164 ml/l, iar la novac a fost de 5/590 ml/l. Rezultatele studiului arată faptul că acest metal este deosebit de toxic pentru speciile de apă dulce.

INTRODUCTION

Group of metal elements for example Cu, Fe, Mn and Zn are necessary for the survival of living things. Another group of metals are heavy metals. This group of metals, unlike the other group are the non-essential (Di-Giulio and Hinton, 2008; Hedayati et al., 2010). The heavy metals combined with the organic molecules will accumulate in the tissues. This process, is eventually leading to contamination of food and destruction of food chain (Kalay et al., 1999); the heavy metal accumulates in the tissue of living organisms and, moving along the food chain, is causing a threat to food safety. Previous studies have shown that some of the human activities such as the oil extraction dispose industry and hospital waste are leading to increased concentrations of heavy metals such as Hg and Cd in the environment. (Tavakoly Sany et al., 2011)

Age, height and weight, gender nutritional habits, the environmental requirements, the concentration of heavy metals in sediment and water, an important determinant of the organs accumulation of heavy metals in fish (Demirak et al., 2006). As well as grass carp and bighead carp are omnivorous fish; they eat their foods from the water surface and bottom sediments (Satari et al., 2007).

The 96 h LC50 tests is a method for finding the toxicity of various elements; in other words, using this method, the amount of strength and survival of different species, in face of different concentrations of pesticide and other risk factors, can be determined (Hedayati et al., 2014); Whenever the concentration of 96 h LC50 is lower, the toxicity is stronger. Heavy metals have a low 96h LC50 (Johnston et al., 2002).

Until now, few studies have been done on the toxicity of cadmium (96 h LC50) on freshwater fishes, especially grass carp (*Ctenopharyngodon idella*) and bighead carp (*Hypophthalmichthys nobilis*). Most studies were detected concentrations of heavy metals in the tissue of marine fish. For example, Farakas et al., 2003; Huang et al., 2003; Juric et al., 2011; Askary Sary, 2012 and Chakeri, 2015. The purpose of this study was to evaluate the effects of acute of cadmium concentrations of on mortality rates and survival of the two species of freshwater fish (grass carp and big head carp).

MATERIAL AND METHODS

According to primary survey and laboratory facilities, 250 grass carp (weight 40 ± 4 g) and 250 Big head carp (weight 12 ± 2.6 g) were prepared from the fish farms in Golestan province and moved to the laboratory (Veniro wet lab, Department of Fisheries, Gorgan University of Agricultural Sciences and Natural Resources). After transferring the fishes to the lab, they have been kept in the 280 liters tanks for the two week (250 liters filling volume) in order to adapt of fish to lab condition. During this time, the fish have been fed three meals a day and equivalent to 3% of the weight of the fish (Biomar food). The density of fish in each tank was 50 and physicochemical conditions were similar in all tanks (water temperature 28 ± 2ºC, 7-8 ml/l dissolved oxygen, 7/4 to 8/1 pH and ammonia 0/04 ± 0/03 ml/l).

After acclimating, 147 fish were selected randomly and were split into seven treatments (0, 0.2, 1, 2, 6, 10 and 15 ml/l Cadmium chloride) and three repetitions (number of fish in each treatment was 21). Fish were exposed for 96 hours to different concentrations of cadmium chloride. The death count in intervals of 24, 48, 72 and 96 hours and the dead were removed from the tanks of test. The fishes were not fed 18 hours before the main test and during the main test. The physicochemical condition of the water at the time of testing the toxicity of cadmium, minus the concentration of cadmium chloride was similar the previous stage (stage adaptations).

Acute toxicity of Cadmium was estimated based on Hotos and Vlahos; lethal concentration of Cadmium (for 50% of the population) in intervals of 24, 48, 72 and 96 hours (24 h LC50), 48 h, 72 h and 96 h were estimated through probit test with a 95% confidence. To find the correlation between different concentrations of cadmium on mortality Spearman test (2-tail) was used.

RESULTS AND DISCUSSION

Specific endpoint results of mortality effects of cadmium for studied fishes are in table 1.

Table 1: Mortality effects of cadmium for studied fish.

Concentration (mg/l)	Number of mortality							
	24 h		48 h		72 h		96 h	
	Grass carp	Big head	Grass carp	Big head	Grass carp	Big head	Grass carp	Big head
0	0	0	0	0	0	0	0	0
0.2	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	4	0
6	3	0	5	1	7	3	14	7
10	7	5	11	9	18	13	21	21
15	8	10	15	15	21	21	21	21

Also, the results showed 96 h LC50 of cadmium for grass carp was 5.264 mg/l and for bighead carp was 6.590 mg/l (Tab. 2); there was significant difference between 96 h LC50 of cadmium in the grass carp compared to the bighead carp, ($P < 0.05$).

Table 2: Lethal concentration of cadmium (96 h $LC_{10\text{-}95}$) for grass carp and big head carp.

Point	Concentration (mg/l)							
	24 h		48 h		72 h		96 h	
	Grass carp	Big head	Grass carp	Big head	Grass carp	Big head	Grass carp	Big head
LC10	6.748	8.628	4.911	6.795	3.793	5.791	2.530	5.096
LC20	9.635	10.887	6.976	8.567	4.937	6.889	3.468	5.140
LC30	11.717	12.324	8.465	9.844	5.762	7.380	4.045	5.160
LC40	13.496	13.551	9.737	10.955	6.467	7.657	4.143	5.334
LC50	**14.159**	**13.698**	**9.926**	**10.995**	**6.126**	**7.989**	**4.164**	**5.590**
LC60	16.822	15.845	12.115	12.975	7.785	9.621	5.804	6.846
LC70	18.600	17.072	13.387	14.066	8.490	10.297	6.382	7.119
LC80	20.682	18.805	14.876	15.343	9.315	11.088	7.059	7.440
LC90	23.570	20.500	16.941	17.114	10.459	12.186	7.998	7.884
LC95	25.956	22.145	18.646	18.577	11.404	13.092	8.773	8.250

Fish, in various concentrations of cadmium chloride, had symptoms of with cadmium poisoning, such as: anxiety, colour vision, increased mucus secretion and death with the open mouth.

Toxic heavy metals are the main group of pollutants in aquatic environments; a large portion of this metal enters aquatic environment due to the human activities (Humtsoe et al., 2007). Monitoring the heavy metals toxicity was important for scientists, nutrition, medical and environmental researchers.

The results of this study showed that cadmium was toxic for grass carp and bighead carp. Lethal concentrations of cadmium (96 h LC50) for grass carp was less than for bighead carp; this difference, in addition to differences in the two species could be due to their size.

Pandey and Madhuri (2014) examined heavy metal toxicity in animals and fish; for this aim they studied on Hg, Pb, Cu and Cd concentrations in the environments, fishes and other animals. They said that heavy metal toxicity depends on the fish species and their habits. This section of their results was similar to present study.

Studies Chakeri et al. (2013), Vinodhini and Narayanan (2009) and Spehar (1976) found that heavy metal poisoning causes anxiety, increased mucus secretion and eventually death. Also, they said different fish species, had different sensitiveness to heavy metals. The results of the study were similar to our study.

Comparing the present study results with the results of previous studies, the toxicity of cadmium (96 h LC50) had been showed from 1.85-5.30 for *Corophium volutator* until the 2.91-4.28 ml/l for *Corophium orientate*, depending on the species, nutrition and the environment (Ciarelli, 1994; Onorati et al., 1999; Chen and Folt, 2000).

Level 96 h LC50 of Cadmium for aquatic species depending on the aquatic species type or metal type is different; for example, Spehar (1976) Level 96 h LC50 of Cadmium for *Mugil cephalus* and *Jordanella floridae* had set 28.0 and 2.5 ml/l, respectively. Das and Banerjee (1980) reported 300.0 and 175.0 ml/l Cadmium for *Lebio rohita* and *Heteropneustes fossilis*, respectively. Eventually, Smet and Blust (2011), expressed, after four weeks, the whole population of common carp that were exposed to cadmium (two ml/l) for 96 hours were died.

CONCLUSIONS

According to the results of this study, grass carp and bighead carp species can be used as biological indicators, howeverhis aim requires further study and higher pervasive. 96 h LC_{50} of cadmium chloride for grass carp was 4.164 ml/l and for big head carp was 5.590 ml/l that showed cadmium is highly toxic for this species. The effect of two or more heavy metals on the health of fish and toxicity of heavy metal could be the fields of next studuies.

ACKNOWLEDGEMENTS

The study was done by technical and scientific support of Gorgan University of Agricultural Sciences and Natural Resources. We thank the efforts of Mr. Jafar A. and all those who helped us.

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EFFECTS OF ENVIRONMENTAL POLLUTION ON FISH: A SHORT REVIEW

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DOI: 10.1515/trser-2017-0005

KEYWORDS: heavy metals, herbicide, gill, kidney, liver, histopathology.

ABSTRACT

Environmental contaminants, such as heavy metals and pesticides, are the most important toxic compounds of aquatic habitats. Heavy metals enter the aquatic environments via natural and anthropogenic pathways while the only source of pesticides is the anthropogenic usage of different types of pesticides including fungicide, insecticide and herbicide. Fish larvae and fingerlings are the most vulnerable life stages of fish which could be severely affected by pesticides as non-target organisms as well as by heavy metal pollution. The most important tissues affected by these pollutants are the gill, kidney and liver. Histopathological alterations of these vital organs could affect the survival rate, biological activities, osmoregulation, reproduction, buoyancy, etc., which finally could lead to failures in stock recruitment and population changes.

ZUSAMMENFASSUNG: Auswirkungen der organischen Gewässerbelastung auf Fische: ein kurzer Überblick.

Umweltgifte wie beispielsweise Schwermetalle und Pestizide sind die wichtigsten toxischen Komponenten aquatischer Lebensräume. Schwermetalle gelangen in die Gewässer über natürliche und anthropogen bedingte Pfade, während die einzige Quelle für Pestizide in der anthropogenen Nutzung ihrer verschiedenen Typen liegt, einschließlich Fungizide, Insektiizide und Herbizide. Fischlarven und Kleinfische sind die verletzlichsten Lebensstadien der Fische, die als Nicht-Zielorganismen stark durch Pestizide, aber auch durch Schwermetallbelastung beeinträchtigt werden. Die durch diese Verschmutzer am stärksten gefährdeten Gewebe sind Kiemen, Nieren und Leber. Histopathologische Veränderungen dieser vitalen Organe können die Überlebensrate, die biologischen Aktivitäten, die osmotischen Vorgänge, Vermehrung, Schwimmfähigkeit etc. gefährden, die schließlich zum Stillstand in der Bestandserweiterung der Fschbestände und zu Populationsveränderungen führen können.

REZUMAT: Efectele poluării mediului asupra peştilor: o scurtă trecere în revistă.

Poluanții precum metalele grele și pesticidele sunt cele mai importante componente toxice din habitatele acvatice. Metalele grele pătrund în mediile acvatice pe căi naturale și antropice în timp ce pesticidele au o singură sursă, anume utilizarea de către om a diferitor tipuri de pesticide, inclusiv fungicide, insecticide și ierbicide. Larvele și alevinii sunt stadiile cele mai vulnerabile în cazul peştilor, care pot fi afectați grav de poluarea cu pesticide deşi nu sunt organismele vizate de acestea, dar și de cea cu metale grele. Principalele țesuturi afectate de acești poluanți sunt branhiile, rinichii și ficatul. Modificările histopatologice ale acestor organe vitale pot afecta rata de supraviețuire, activitatea biologică, osmoreglarea, reproducerea ș.a.m.d., ceea ce se poate traduce în final în incapacitatea refacerii stocurilor și în modificări de ordin populațional.

INTRODUCTION

Pollution and the effects of various pollutants on fish has been researched and is still under study. The most numerous contaminants are heavy metals and pesticides; even if there are up-to-date researches on the impact of nano-particles (Khoshnood, 2016).

Heavy metals are one of the most studied contaminants worldwide. It has been shown that they reach in to the aquatic ecosystems in a number of different ways. Two major pathways have been shown: natural and anthropogenic. As natural ways for heavy metals entering aquatic environments one can name: volcanic activity (terrestrial or marine), windblown dust, forest fires and erosion of ore bearing rocks (Khoshnood et al., 2012).

Anthropogenic pathway of heavy metals is due to urban, agricultural and industrial wastewater and dumping of solid waste in coastal environments. Despite the large scale of natural source for heavy metals, it has been estimated that the anthropogenic source for such heavy metals (Hg, Pb, Zn, Cd and Cu) are about one to three orders of magnitude greater than natural release. The principal cause of anthropogenic pollution of heavy metals is industrial wastewater which influenced the various aquatic environments such as ponds, lakes, streams, rivers, seas and oceans (Khoshnood et al., 2012).

Worldwide usage of pesticides and high diverseness of all these substances make them as one of the most important contaminants of aquatic habitats. Beside their impact on target organisms, the impact of these contaminants on non-target organisms is high (Khoshnood, 2016). It has been estimated that a large part of used insecticides and herbicides (about over 98% and 95%) reach to the non-target organisms (USEPA, 2002). Different ways of motility for these compounds has been described, for instance, wind can carry out the pesticides from one field to another, runoff (from excessive watering system or rain) can lead them to different water bodies, even undergrounds water reservoirs; and by all these ways pesticides can affect the non-target organisms. Human flaws during different stages of pesticide production, transportation, storage and usage are also affects the other species (USEPA, 2002).

However, wide variety of pesticides has different environmental destination and activity due to their specific chemical properties. Due to undesirable effects of pesticides on non-target organisms, many of these compounds have been banned through time and also many others are under strict regulations for use. Also for reducing their effects on non-target organisms, today pesticides are more species-specific, less motile and less persistent (Khoshnood et al., 2014).

Effects on different life stages

All organisms have a life cycle with different stages in which some stages are more vulnerable to environmental alterations and contaminants than the others. It has been shown than the most sensitive stages of fish life cycle is the early developmental stages such as embryonic and larval stages. Beside the long time exposure to low levels of contaminants which could seriously impact the organism, it has been underlined that also short time exposure could influence the feeding and buoyancy behaviors, osmotic regulation, growth and survival of the organism and because of that negatively influence the recruitment of population (Khoshnood, 2016).

Fish tissues as biomarker

The biomarker concept is using for biological alteration associated to environmental pollutants and risks which could be physical, chemical and/or biological (Van der Oost et al., 2003).

In the past two decades, usage of biomarkers as an effective tool in environmental contamination studies of aquatic habitats has been developed.

In the present, a large range of researches, such as biochemical, molecular, physiological, morphological, histopathological, community, and population, are use in monitor the impact of various pollutants, various concentrations of a single contaminant, environmental quality, or the habitat and ecosystem succession (Khoshnood, 2016).

Histology is a useful tool to assess the exposure to contaminants such as the degree of pollution in acute, sublethal and chronic exposure (Bernet et al., 1999).

Generally, using molecular and biochemical biomarkers are more accurate and specific but linking them to environmental alterations is more difficult. Changes in population responses are conveniently to link with environmental health and management, even if researching of such feedback was more labored, less specific and only become detectable once the ecosystem has damaged.

Researching of histocytopathological modifications is average easy and is largely used as biomarkers in various observations on the effects of pollutants on environmental health including on fish (Khoshnood, 2016).

Several tissues and organs of various fish were repeatedly used as biomarker of fish contamination due to their specific characteristics. Among these organs, the gill is one of the most common tissues in environmental contamination studies due to its wide surface area in contact with surrounding water, high activity in ion transport, high amount of blood, etc. (Khoshnood, 2016).

Other common tissues in such studies include the liver, kidney, intestine, skin and brain. All these tissues have important roles in life of a fish and some, such as liver, has metabolic pathways for eliminating the contaminants (Khoshnood, 2016).

Effects of heavy metals on fish

Gill

Gills are one of the most important organs of all fish because of the wide surface area with surrounding water. As a result, the respiratory system is frequently the first organ to be affected by pollutants (Khoshnood et al., 2011).

One of the most frequent heavy metals in aquatic environments is mercury, which received a great deal of attention after discovery of Minamata disease in Japan in the 1950s. It is revealed that the fate of mercury compounds in the environment greatly depends on the chemical form of mercury and the environmental conditions (Beckvar et al., 1996).

$HgCl_2$ is one of the inorganic forms of mercury in polluted aquatic environments. Results of a case study on the effects of $HgCl_2$ on Persian sturgeon, *Acipenser persicus*, fry, showed that at the short term exposure (acute) of fish to a low level of $HgCl_2$ as 15 ppb for 48 hours a wide variety of changes in gill tissue can be happen (Khoshnood et al., 2011). Hypertrophy of epithelial cells in lamellae, wrinkling of lamellar epithelium, fusion of lamellae, and lamellar hyperplasia (Figs. 1A-E) were the most important alterations observed in that study (Khoshnood et al., 2011). Ultrastructural observation of gills affected by $HgCl_2$ showed some major alterations such as necrosis in filaments and bleeding (Fig. 1F) (Khoshnood et al., 2011).

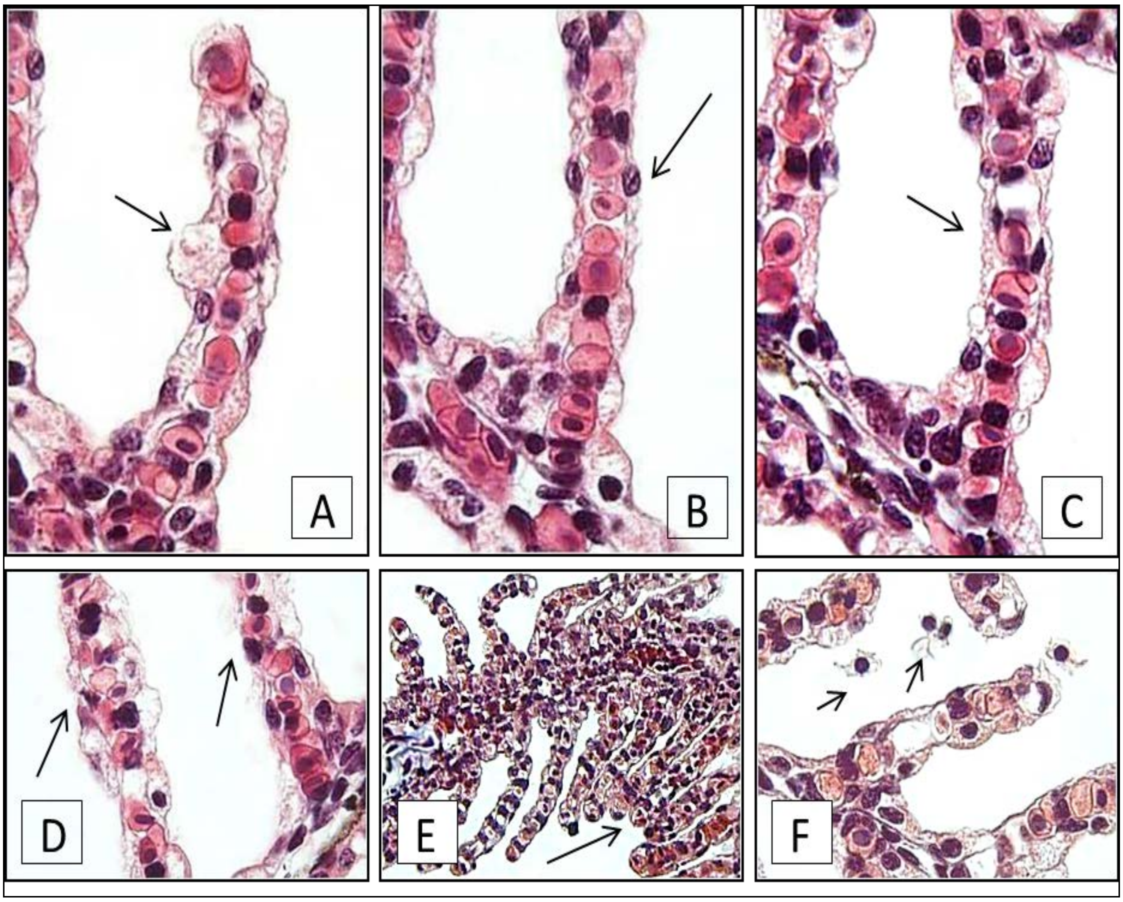

Figure 1: Histopathological effects of $HgCl_2$ on gills of Persian sturgeon, *Acipenser persicus* fry: Hypertrophy of the epithelial cell in lamellae (A). Wrinkling of the epithelium (B and C). Epithelial hyperplasia and epithelial necrosis without blood outcoming (D). Lamellae fusion (E). Necrosis in epithelium with blood outcoming (F) (Khoshnood et al., 2011)

Liver

In a previous study on the bioaccumulation of heavy metals, Ni and V in two flat fishes, *Euryglossa orientalis* and *Psettodes erume*, had revealed that pollution of water with these two metals could affect the liver tissue and make some histopathological alterations. These alterations include degeneration and necrosis of hepatocytes, tissue disruption and haemorrhagie (Figs. 2A-D) (Khoshnood et al., 2010).

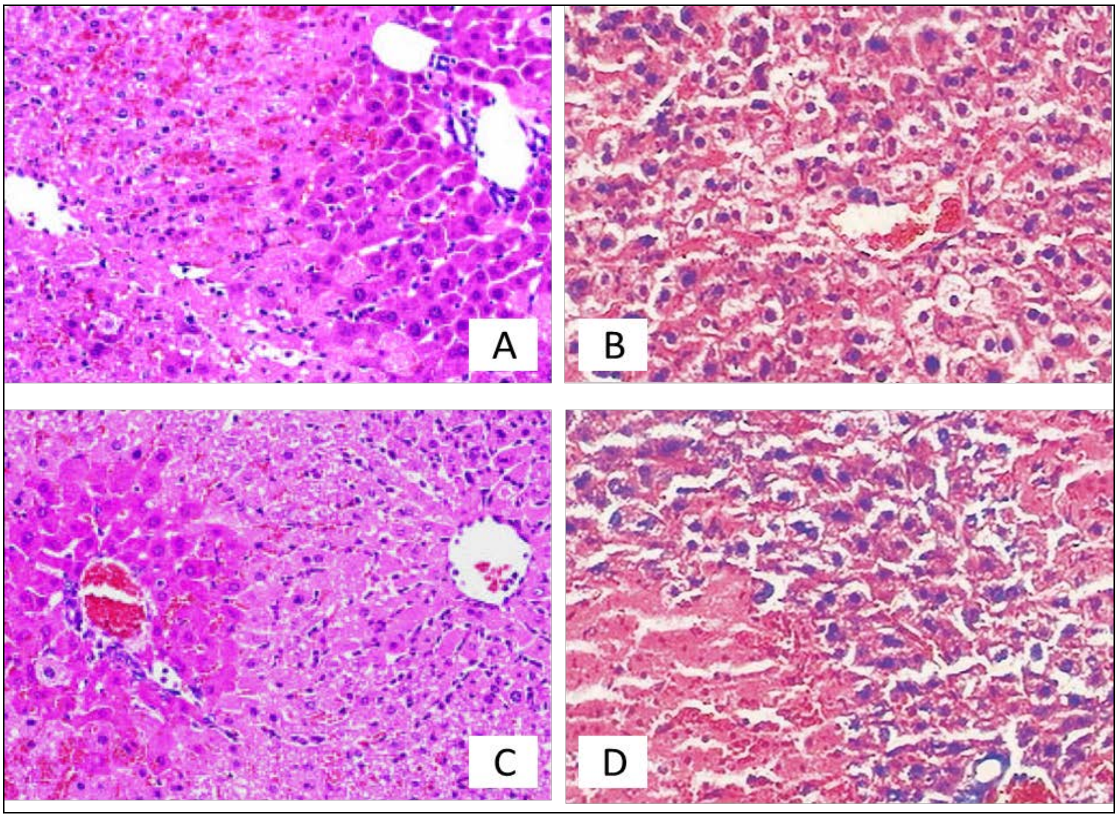

Figure 2: Histopathological alterations in liver of two flat fishes, *P. erumei* (A and B) and *E. orientalis* (C and D): Hemorrhagia, cell necrosis and degeneration were the most histopathological alterations (Khoshnood et al., 2010).

Effects of pesticides on fish

Pesticides include a wide range of compounds including insecticides, fungicides, herbicides, etc., each divided to subgroups of their chemical forms. Among the pesticides, due to the agricultural activities, herbicides represent a large percent of all used pesticides worldwide. One of the most common herbicide is atrazine, which affects the photosynthesis in broad leaf plants and has well known effects on different non-target organisms including frogs, birds, fish and even humans (Giddings et al., 2004).

Gill

In revealing of the impact of atrazine on Caspian kutum, *Rutilus frisii kutum*, fry, it has been underlined that important tissue and cell modifications could be seen due to acute exposure to a sublethal concentration of atrazine as low as 12.47 mgl^{-1}.

These alterations include detachment of the epithelium of the lamellae (Figs. 3A-F, 4E-G), necrosis (Figs. 3C-F, 4J, 5D), lamellar fusion (Figs. 3B, D, E, F, 4C, 5A-D), hyperplasia (Fig. 4C), club shaped lamellae (Figs. 4A and H), collapse of the lamellae (Figs. 5A-D), shrinkage and curling of the lamellae (Figs. 4H, 5A-C), and ultrastructural alterations such as necrosis of the apical microridges of the pavement cells (Fig. 5D). Results of this also showed that the gill ionocytes were fewer in number and larger in size in the atrazine-exposed fish (Khoshnood et al., 2015).

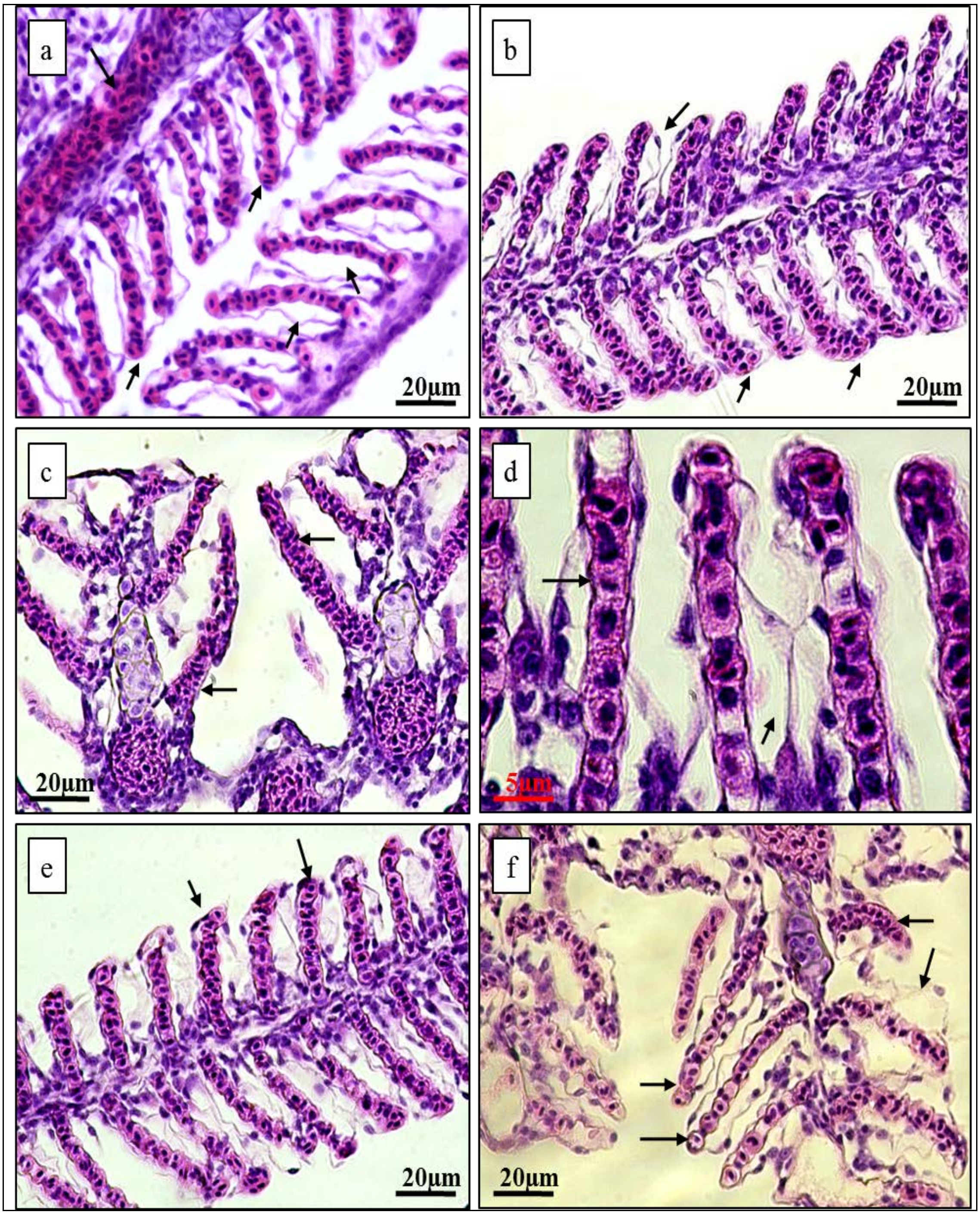

Figure 3: Histopathological effects of atrazine on gills of *Rutilus frisii kutum*, Fingerlings: Lifting up the lamellar epithelium (a and f); thickening of the lamellae (b); blood congestion (a-f); edema in lamellae and filament (b and e); hypertrophy of the pavement cells of the lamellae (d); necrosis (c and f); lamellar fusion (b, d, e and f) (Khoshnood et al., 2015).

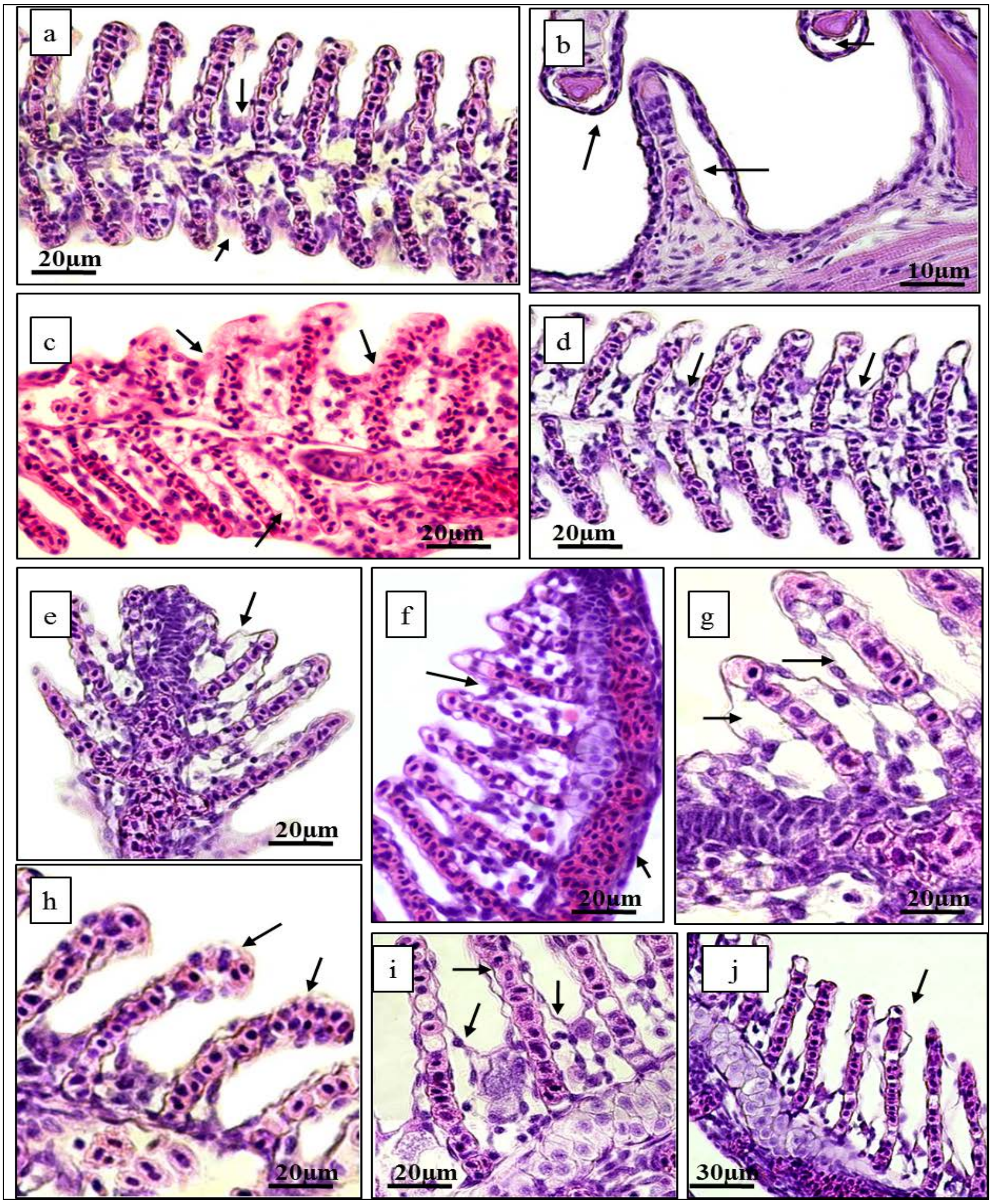

Figure 4: Additional histopathological effects of atrazine on gills of *Rutilus frisii kutum*, Fingerlings: Hyperplasia of the filament's epithelium (a); club shaped lamellae (a and h); lifting up the epithelium of the gill racker (b); hyperplasia of the lamellar epithelium and lamellar fusion (c); edema in epithelium of the filament and the cells at the basis of the lamellae (d, f and i); edema in pavement cells of the lamellae and lifting up of this epithelium (e); blood congestion (f-j); shrinkage of the lamellae (h); necrosis in lamellar epithelium (j) were the most recognizable changes made by atrazine exposure (Khoshnood et al., 2015).

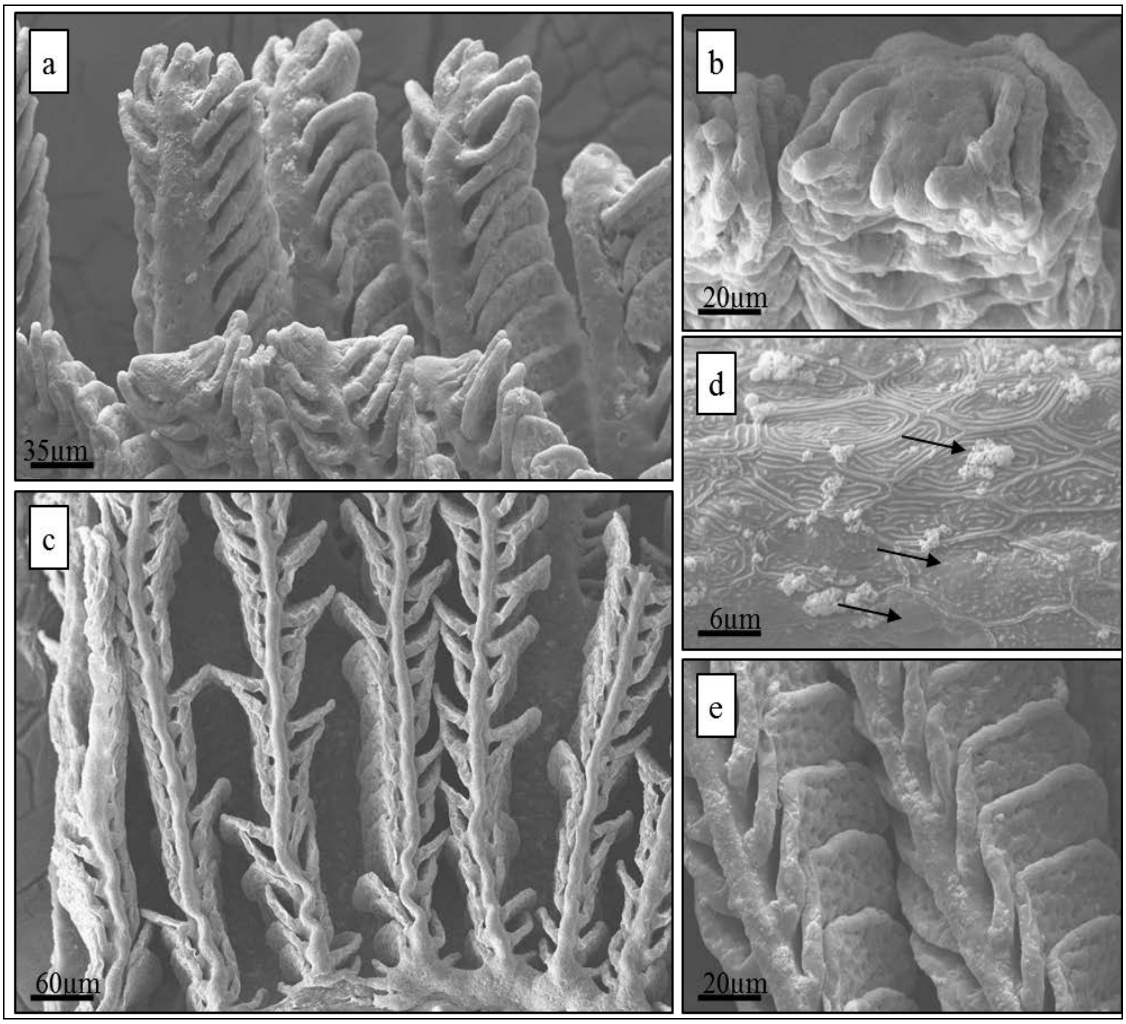

Figure 5: ultrastructural effects of atrazine on gills of *Rutilus frisii kutum*, fingerlings; fusion and collapsing of the lamellae (a, b, c and d); shrinkage and curling of the lamellae at the apical parts of the filaments (a-c); necrosis of the apical microridges of the pavement cells and mucus aggregation (d) (Khoshnood et al., 2015).

Kidney

In a study of the effects of atrazine herbicide during two stages of the life cycle of Caspian kutum, *Rutilus frisii kutum*, for larvae and fry it was found that the damages were more severe in larvae than the fingerlings. The major histopathological effects of acute exposure to a sublethal concentration of atrazine (9.25 ppm and 12.47 ppm for larvae and fry respectively, both for 96 h) were hyperplasia (Figs. 6E, 7B-C), necrosis (Figs. 6C, F, 7A-D), vacuolation (Figs. 6D-F), swelling (Figs. 6D-F, 7F), hypertrophy (Figs. 6D-F), aggregation of hyaline droplets (Figs. 6D-F), and disruption of the haematopitic tissue of the head kidney (Fig. 6C) (Khoshnood, 2015).

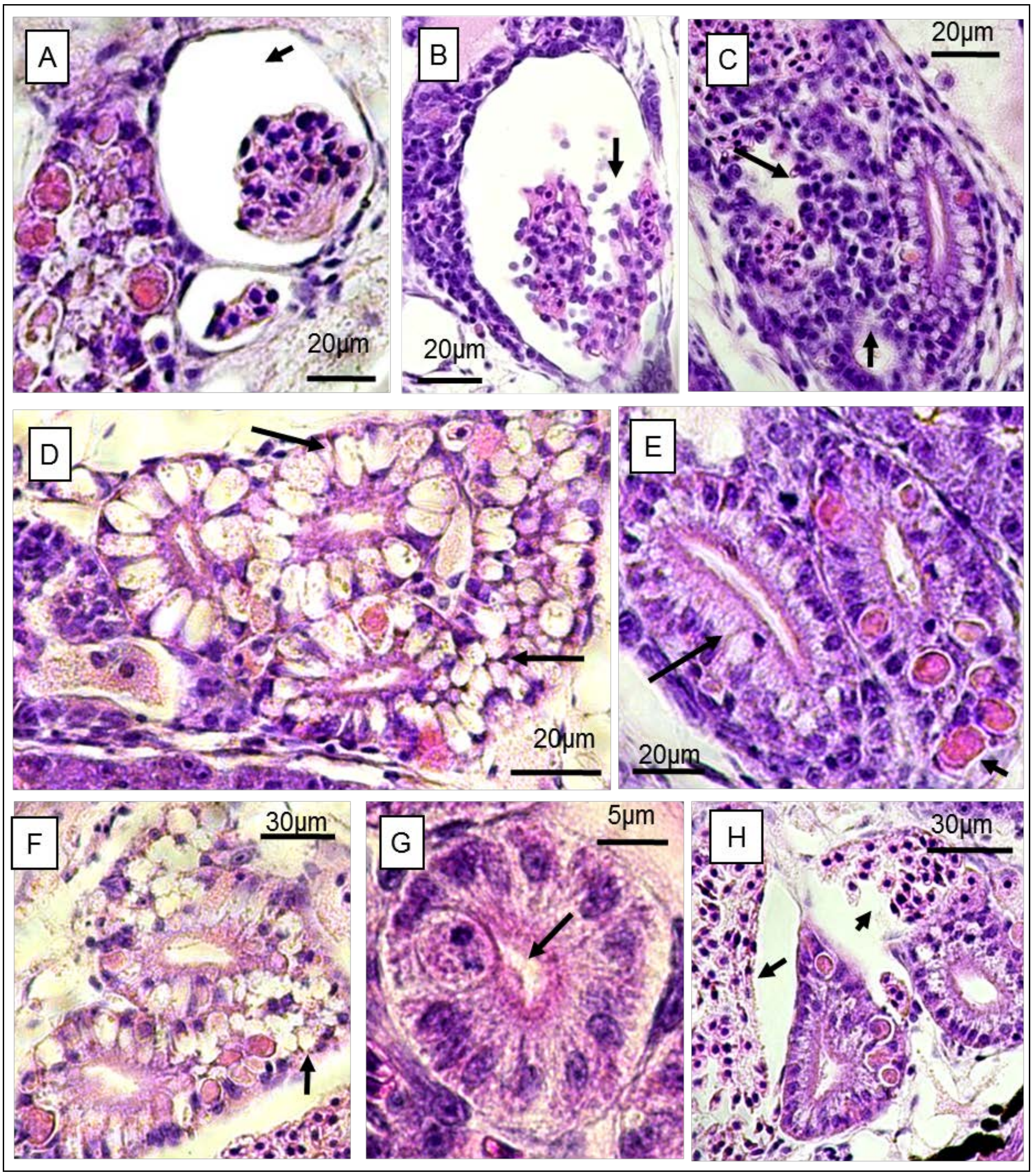

Figure 6: Histopathological effects of atrazine on kidney of *R. frisii kutum* larvae: reduction of the glomerulus and increasing of the Bowman's space (A); necrosis of the glomerulus (B); necrosis and disruption of the haematopitic tissue of the head kidney (C); swelling, hypertrophy, vacuolation and aggregation of hyaline droplets in renal tubular epithelial cells (D-F); hyperplasia of the renal tubular epithelial cells (E); necrosis of the renal tubular epithelial cells (F); decreasing in lumen space and complete congestion of lumen in renal tubules (G); hyperemia (H) (Khoshnood, 2015).

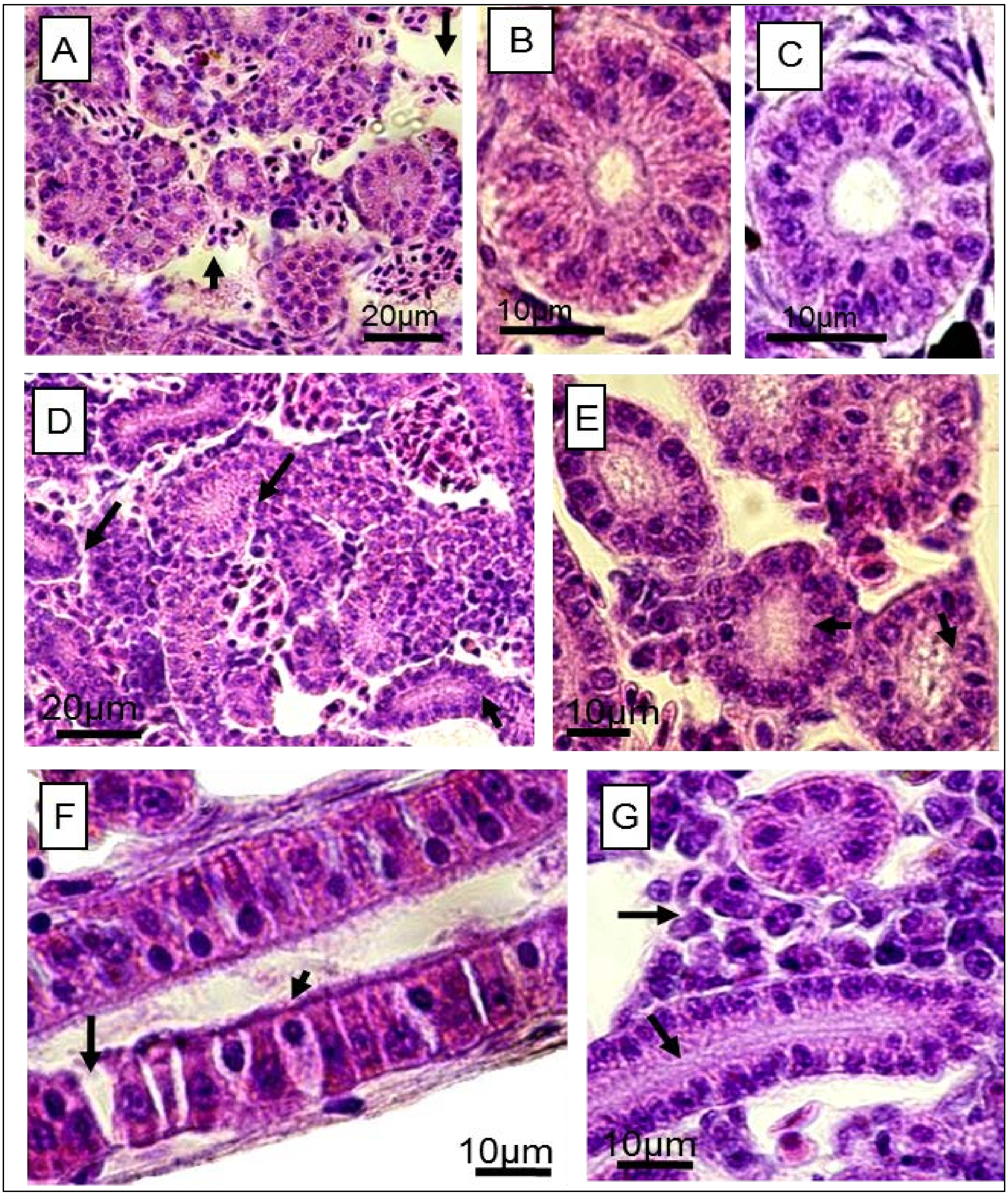

Figure 7: Histopathological effects of atrazine on kidney of *R. frisii kutum* fingerlings: hyperplasia of proximal tubule epithelial cells (B, C) and detachment of epithelial cells from the basement membrane (B, C), Congestion of tubular lumen (D, E, G); necrosis and disruption of haematopoitic tissue in head kidney (A, D); necrosis, swelling and disorientation of ureter epithelial cells (F) (Khoshnood, 2015).

CONCLUSIONS

Results showed that environmental contaminants such as heavy metals and herbicides could affect multiple tissues of fish (gill, liver and kidney), even at low concentrations and acute exposure. Tissue modifications of all these essential organs will decrease the survival rate and biological activities level of organisms such as osmotic regulation, feeding, buoyancy, etc., which lead to population diminution.

Results showed that due to high surface to volume ratio of smaller organism (larvae compare to fingerlings) and also the high rate of cell growth and differentiation in larvae, the effects of environmental contamination on larvae will be more severe than the effects on fingerlings. The results also showed that many tissue alterations made by these environmental contaminants were not specific but generally could be used as a monitoring tool in environmental protection programs.

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PRESENT STATUS OF INTERTIDAL BIODIVERSITY IN AND AROUND MUMBAI (WEST COAST OF INDIA)

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DOI: 10.1515/trser-2017-0006

KEYWORDS: intertidal, mollusc, benthos, algae, echinoderm, crustacean, fish.

ABSTRACT

During the present investigation, Girgaon, Marine Drive, Haji Ali and Gorai Creek in Mumbai were selected for biodiversity assessment following a protocol for natural geography in shore areas. Fifty nine macrobenthic molluscs, arthropods, coelenterates and echinoderms at these sites were recorded. The maximum density of gastropods and clams was observed at Marine Drive shore. At Gorai Creek, there were plentiful *Telescopium telescopium*, *Potamidus cingulatis*, mudskipper and fiddler crabs. Studies shows that the biodiversity status of the selected sites varies with respect to location, type of substratum and season. Pollution was observed to have a noticeable effect on clams at Girgaon coast, where many *Paphia textile* shells were observed to be filled with mud and coated with black colour.

RESUMEN: Situación actual de la biodiversidad intermareal en y alrededor de Mumbai (Costa Oeste de la India).

Durante la investigación actual, Girgaon, Marine Drive, Haji ali, Gorai Creek en Mumbai fueron seleccionados para la evaluación de la biodiversidad siguiendo la geografía natural en el protocolo de las áreas de la orilla. Se recodificaron 59 moluscos macrobentónicos, artrópodos, celentéreos y equinodermos en estos sitios. Na costa de Marine Drive, la densidad máxima de los gastrópodos y de la almeja. En el Gorai Creek, muchos *Telescopium telescopium*, *Potamidus cingulatis*, pez de fango y cangrejos violinistas fueron detectados. Los estudios sobre el índice de diversidad de Shannon y Simpson, el índice de riqueza de Margalef y el índice de equidad de Pielou muestran que el estado de la biodiversidad de los sitios seleccionados varía con respecto a la ubicación, tipo de sustrato y estación. El efecto de la contaminación en la costa de Girgaon se observó en las almejas *Paphia textile* donde las conchas rellenas de fango y cubiertas de manchas de color negro fueron observadas.

REZUMAT: Situația actuală a biodiversității din zona litorală în și dimprejurul regiunii Mumbai (Coasta de Vest a Indiei).

În cadrul investigațiilor din Girgaon, Marine Drive, Haji ali și pârâul Gorai în Mumbai au fost alese pentru investigarea biodiversității urmând protocolul de geografie naturală a zonelor de țărm. Au fost înregistrate 59 de moluște macrobentice, artropode, celenterate și echinoderme la aceste locații. La țărmul Marine Drive a fost înregistrată o densitate maximă a gastropodelor și scoici. La pîrâul Gorai au fost înregistrate următoarele specii: *Telescopium telescopium*, *Potamidus cingulatis*, pești amfibii și crabi. Studii ale indicilor de diversitate Shannon și Simpson, indicele Margalef și indicele Pielou arată că situația biodiversității din locațiile selectate variază în funcție de amplasare, tip de substrat și sezon. Efectul poluării pe coasta Girgaon a fost observat în cazul scoicilor unde multe exemplare de *Paphia textile* au fost găsite pline de mâl și acoperite cu o substanță de culoare neagră.

INTRODUCTION

India is well known arround the world for a very high aquatic biodiversity (Jeeva et al., 2011; Sanghvi et al., 2015; Ramanibai and Govindan, 2015). Mumbai (18º53' to 19º16' N latitude and 72º48' to 72º53' E longitude) is an island situated on the west coast of the Indian peninsula on the Arabian Sea. Mumbai was built on cluster of seven islets. Now it forms a mass of islands, measuring three miles in width. This area northern end to rock at Colaba and its southern end at the Northern Kokan coast. A deep natural harbour is located to the east and at the south part off Colaba Point there is the Prong's Reef reefs area, which is unprotected in spring low tide. The rocks of these reef areas lengthen up to the Nariman Point. The island is linked at its northern part with the larger Salsette Island by two causeways, at Mahim one and the other at Sion. (Jaiswar, 1999)

Mumbai is a significant industrial hub in India, with representatives of everything from textiles to petrochemicals, and it is responsible for half of India's foreign trade. Moreover, Mumbai has a very long coastline of 100 km. Although the majority of the population of Mumbai is provided with houses and sanitary facilities, almost half of the city's 12 million residents are either slum dwellers or homeless. They occupy 6% of the city's land. The sewage from the residential areas of Colaba, Worli, Malad and Bandra is into the coastal area through marine outfalls with a capacity of 4.1 MLD, 756.4 MLD and 0.80 MLD, whereas sewage from other area is released into neighboring creeks. Due to human pressures, the shore area of Mumbai is highly degraded. The shore zone of Mahim used to have a very rich faunal diversity some thirty years ago, but now it has deteriorated to such a condition that the benthic fauna has been totally wiped out. (Jaiswar, 1999)

Since massive amount of domestic and tannery industrial waste is released into the Mahim shore area, the area has been converted to an ecological dead-zone. Similar conditions are likely to occur in the remaining intertidal areas in and around Mumbai. Due to increasing pollution in shore waters around Mumbai, there are reports of habitat destruction and species loss. Nearly 8% of industries in the country are located around Mumbai in four large industrial clusters namely Trans Thane-Belapur belt, Kalyan-Ulhasnagar-Ambernath belt, western bank of Thane Creek and around the Patalgang Amba rivers. Patalganga, Amba and Ulhas rivers, and Thane Creek are the receivers of a mixture of waste. The amount of water supplied for drinking, commercial, industrial and recreational purpose in Mumbai was 3,193 MLD whereas for the year 2021 it is estimated to be 5,388 MLD (Nallathiga, 2006). Therefore plenty of waste water is generated from domestic and industrial sources and majority of it is released directly into shore waters in Mumbai.

For many years, there has been a long-term study of an intertidal area in and around Mumbai. Bal and Parham (1945, 1946) recorded normal chemical and physical conditions of shore water of Bombay harbour with an abundance of plankton. Most of the earlier reports on the intertidal diversity of Mumbai are limited in goal (Abercrombie, 1893; Melvill and Standen, 1910; Subramnyam et al., 1949, 1951, 1952; Bhatt, 1959). Therefore, this investigation selected four shore areas in and around Mumbai to assess their biodiversity status and the impacts and effects of human activity on biodiversity patterns.

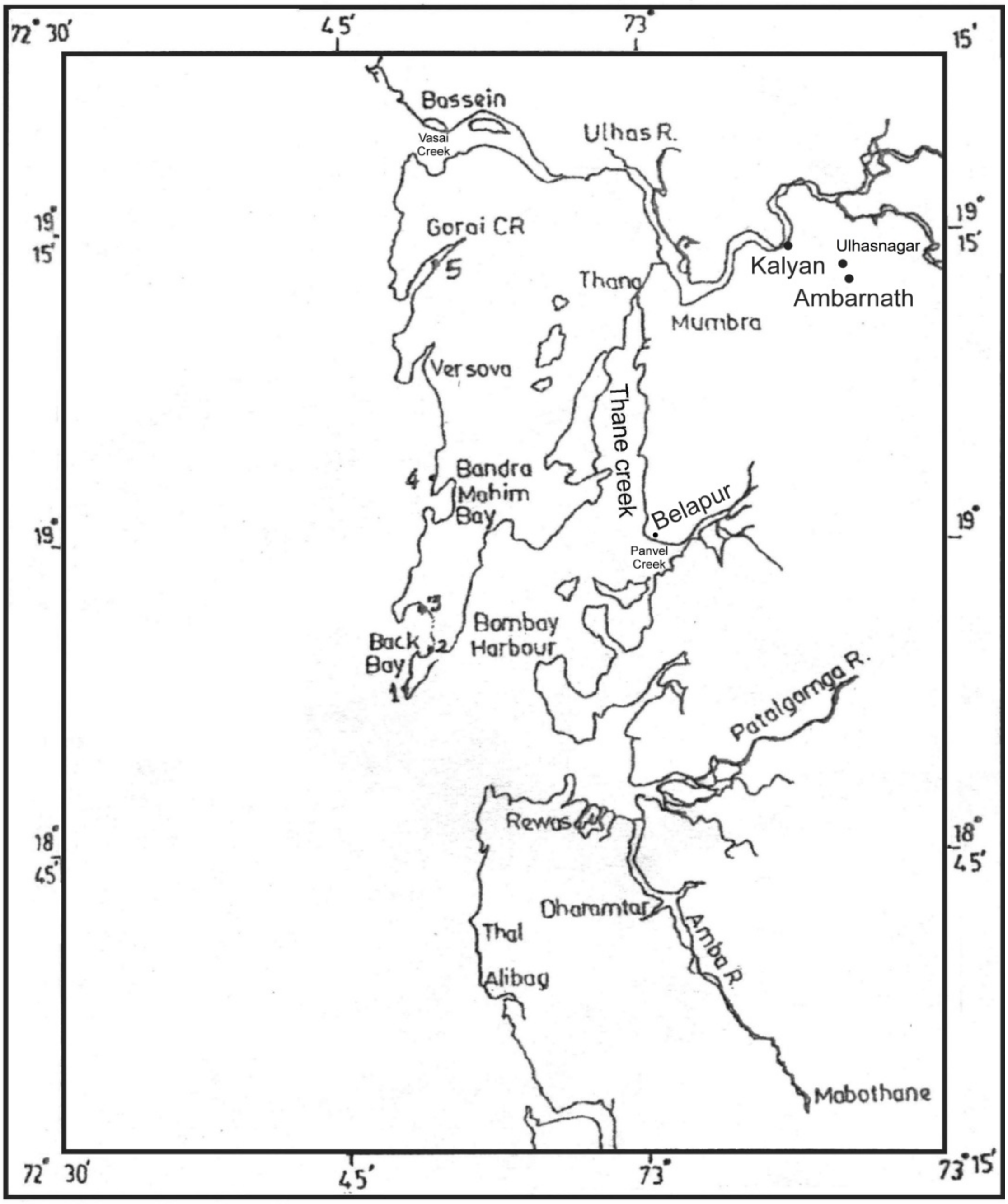

Figure 1: Map of Mumbai showing selected shore area study sites.

MATERIAL AND METHODS

The Study Sites

Intertidal zones at Girgaon, Marine drive, Haji ali in the south and Gorai Creek in the north of Mumbai were selected for the present investigation. The Girgaon Chowpatty Intertidal Area is located in south Mumbai and is popular as, it constitutes a part of the Queen's Necklace shore. It is sandy in nature and is one of the famous recreational areas in Mumbai. Even though it has a large pan of coarse sand, biggest of the uppermost part of it is jammed with food and snack stalls. Furthermore thousands of people visit it everyday and maximum human activities takes place here. As a result the shore is in a deteriorating condition.

In addition, there is extensive storage of garbage including plastic bags, flowers, waste paper, which brings more stress on marine biota, especially at the upper intertidal zone, the lower part of shore area still possesses a variety of fauna. The sand at this site is composed of variety of mineral species in both the coarser and finer fractions. Disintegrated shell matter, which occurs in both coarse and fine fractions along with coral fragments and microfossils, was found to make up a considerable portion of beach sediment. The common minerals of the light fraction like calcite, feldspar and clay were also noticed substantially at this shore. Calcite, which is found to be a major mineral constituent of sand here, is mainly derived from the disintegration of larg mollusc shells, corals and foraminifer skeletons. The middle and lower intertidal areas of Girgaon Chowpatty have muddy substratum of mixed silt and sand, providing a suitable habitat for burrowing bivalves like blood clam.

At the Girgaon Chowpatty coast, there is significant release of domestic waste containing big quantities of particulate matter. Such particulate matter settles down on sandy shore and forms a muddy substratum. Moreover every year large number of Ganpati idols are immersed here after Ganpati festival. All these idols are create of Plaster of Paris and clay, which when sink in sea water dissolve to produce a fine-grained substance which forms a muddy base after combining with sand. An area with mudd of this kind is evident in the intermediate intertidal zone. Wave action is minimal on the muddy shore where the slope is gentle and the area is called a Mudflat. The water content of this area is considerably high at low tide.

The Marine Drive and Haji Ali coasts are rocky. The Marine Drive coast sector is three km long at the shore end at Girgaon Chopatty. It also part of the Queen's Necklace shore area. As with Girgaon Chowpatty, both Marine Drive and Haji Ali are also very touristic areas, with numerous hotels which are located near the Marine Drive sector. The waste released here combines with the fine grained material from dissolved idols at Girgaon Chowpatty, and collectively have a great influence on the physiochemical property of the water and ultimately the biodiversity of Marine Drive sea shore. The upper intertidal area is artificially reclaimed with large size cement tetrapod shape blocks and a road wall.

Mahalaxmi-haji-ali shore is located in South Mumbai. The area mainly consists of basalt rocks in the upper intertidal areas with sporadic patches of sand. Nevertheless, upper and partialy the middle zone are muddy with big pebbles. Because dousehold discharges are released here, there is an continuous process of muddy base creation.

Gorai Creek which transects the northwest portion of Mumbai extends 12 km inland through vast mangrove mudflats and low lying marshy areas. The shallow creek of Gorai is influenced by semi-diurnal tides. The discharge of domestic effluent in the inner part of the creek exerts some influence on the ecosystem.

Sampling method

The picked shore sectors in and around Mumbai area were inspected monthly at the same time with low tides from July 2009 to January 2011. The principal sampling method was quadrat sampling following the guidelines given by NaGISA (Natural geography in shore areas). Voucher specimens of macro benthic species were collected from the respective shore areas, brought to the laboratory for identification and deposited in departmental specimen repository. Identification of molluscs was done following the reports by Subramanyam et al. (1949, 1951 and 1952). The taxonomy of crabs were identified using a report by Chhapgar (1957, 1958), and other groups like crustacean and annelids were identified using a paper by Bhatt (1959).

RESULTS AND DISCUSSION

The of microbenthic species diversity recorded in selected shore sectors in and around Mumbai is given in table 1. The data reveal that in the macrobenthic fauna prevails the gastropods and the bivalves. Further shore specific distribution of the benthos was also noticed. Plastic bottles, plastic food wrappers and polyethylene bags were also noticed on the surface water up to 100 meter inside from the coast of all the stations.

Girgaon chopatty shore: Since Girgaon's substrate is sandy-muddy in nature, it is dominated by clams and gastropods. Of the clam family, the most abundant species were *Paphia textile* and blood clam *Arca* sp. Of the gastropod family, *Babilonia spirata* dominated. Nevertheless, the other macrobenthic species presence was sparce, particularly in comparison with other study areas. There is significant deposition of silt and organic matter which support the local detritus feeding species. Nevertheless, the breaking down of particles leads to the detection of oxygen which induces in the formation of Sulphite black layer. This layer fluctuates in various sectors of the shore, and the interaction between alluvium and leads microorganisms induce the Hydrogen sulphite creation. Such black layer was noticed here and shells of most gastropods inhabiting this area were found to be coated with blackish colour.

Marine Drive shore: 34 macrobenthos species were sampled in the Marine Drive rocky shore area. Dominant in the macrobenthos were the molluscs (24 species) and the bivalves (eight species). There was clear dominance of *Euchelus asper* (8-78%) followed by *Gafrarium divaricatum* (8-21%) and *Pyrene atrara* (0-28%). The dominance of gastropod and clams in this study area was similar to that reported by Jaiswar and Kulkarni (2005). The crustaceans were essentially represented by four crab species (viz. *Eriphia* sp. (Red eye reef crab), *Petrolisthes* sp. (Red porcelain crab), *Schizophrys aspera* (spider crab) and *Charybdis japonicas* (Asian paddle crab)), two pistol shrimp species (viz. *Alpheus euphrosyne*, *Alpheus heterochaelis*) and one barnacle species (*Balanus amphitrite*), found in and on the boulders and rocks of Marine Drive shore. Large-sized *B. amphitrite* was noticed in the middle zone. A juvenile octopus and Moray eel were also sampled exceptionally from the lower intertidal sector in the research period. Cement terapods put here found to provide substratum for Neretidae, oysters and *Balanus* species to colonise. There are also some species of crabs hiding under the blocks.

Table 1: Diversity of Macrobenthos species at Girgaon Chopatty (GIC), Marine Drive Shore (MD), Haji Ali shore (HA) and Gorai Creek (GC) in Mumbai.

Pelecypoda

Family	Species	Occurrence	Place
Mytilidae	*Modiolus emerginatus* (Benson, 1858) *Perna viridis* (Linnaeus, 1758)	Rare Common	GIC MD,GC,HA
Veneridae	*Katelysia opima* (Gmelin, 1791) *Gafrarium divaricatum* (Gmelin, 1791) *Gastrena polygona* (Gmelin, 1791) *Venerupis microphylla* (Deshayes, 1853) *Dosinia gibo* (Gmelin, 1791) *Cardita antiquata* (Linnaeus, 1758)	Common Common Common Common Common Common	GC HA HA GIC MD, GIC, HA MD, GIC, HA
Ostreidae	*Crassostrea cucullata* (Born, 1778) *C. gryphoides* (Schlotheim, 1813) *Saccostrea cucullata* Ignaz von Born 1778	Common Common Common	MD, HA, GC HA GC, HA, GRC

Gastropoda

Family	Species	Occurrence	Place
Trochidae	*Trochus stellatus* (Gmelin, 1791) *T. tentorium* (Gmelin, 1791) *T. radiatus* (Gmelin, 1791) *Clancules ceylonicus* (Nevill, 1869) *Euchelus asper* (Gmelin, 1791)	Common Common Common Common Common	HA MD, HA MD, HA HA, MD, HA
Neritidae	*Nerita oryzarum* (Recluz, 1841) *N. albicilla* (Linnaeus, 1758) *Nerita crepidularia* (Lamarck, 1822) *N. pulchella* (Recluz, 1843)	Plentiful Common Common Common	MD, HA MD, HA HA HA
Planaxidae	*Planaxis sulcatus* (Born, 1778)	Plentiful	MD, HA
Potimididae	*Potamides cingulatus* (Gmelin, 1791) *Telescopium telescopium* (Linnaeus, 1758)	Plentiful Plentiful	GC, HA GC
Bursidae	*Bursa tuberculata* (Broderip, 1833) *B. spinosa* (Schumacher, 1817) *B. granulose* (Roding, 1798) *Bursa elegans* (Sowerby, 1835)	Plentiful Common Common Plentiful	MD, GIC, HA, GC MD, HA GC, HA GC, HA
Muricidae	*Thais bufo* (Lamarck, 1822) *Drupa tuberculata* (Blainville, 1832)	Common Common	MD, HA, GC HA
Buccinidae	*Babylonia spirata* (Linnaeus, 1758) *Pyrene atrata* (Gould, 1860)	Common Common	MD, GIC, HA MD
Volemoidae	*Hemifusus pugilinus* (Born, 1778)	Common	MD, GIC, HA, GC
Cypraeidae	*Cypraea arabica* (Linnaeus, 1758)	Rare	MD
Fissurellidae	*Scutus unguis* (Linnaeus, 1758)	Common	MD, HA
Onchidiidae	*Onchidium peronii* (Cuvier, 1804)	Common	MD

Table 1 (continued): Diversity of Macrobenthos species at Girgaon Chopatty (GIC), Marine Drive Shore (MD), Haji Ali shore (HA) and Gorai Creek (GC) in Mumbai.

Cephalopoda

Octopodiformes	*Octopus vulgaris* (Lamarck, 1798)	Common	MD

Crustacea

Xanthidae	*Epixanthus frontalis* (H. Milne Edwards, 1834) *Leptodius exaratus* (H. Milne Edwards, 1834)	Common Common	GC GC
Eriphiidae	*Eriphia* sp.	Common	MD, HA
Majidae	*Schizophrys aspera* (H. Milne Edwards, 1834)	Common	MD, HA
Porcellanidae	*Petrolisthes boscii* (Audouin, 1826)	Common	MD, HA, GC
Portunidae	*Charybdis japonica* (A. Milne-Edwards, 1861)	Common	MD, HA, GC
Ocypodidae	*Uca annulipes* (H. Milne Edwards, 1837) *U. vocans* (Linnaeus, 1758) *Uca dussumieri* (H. Milne Edwards, 1852)	Common Common Common	HA, GC HA, GC GRC
Balanidae	*Balanus variegatus* (Darwin, 1854) *Balanus amphitrite* (Darwin, 1854)	Common Common	GRC, HA MD
Paguridea	*Eupagurus prideauxi* (Leach, 1815)	Common	GRC, HA
Alpheidae	*Alpheus euphrosyne* (de Man, 1897) *Alpheus heterochaelis* (Say, 1818)	Common Common	MD, HA MD, HA

Porifera

Lecosolenidae	*Leucosolenia complicata* (Montagu, 1814) *Tetilla dactyloidea* (Ridley, 1884) *Tethya lyncurium* (Linnaeus, 1767)	Common Common Common	MD, HA MD, HA MD, HA

Coelentelata

Actinidae	*Metridium marginatum* (H. Milne-Edwards, 1834)	Common	MD, HA, GIC

Fish

Gobiidae	*Boleophthalmus boddaerti* (Pallas, 1770) *B. viridis* (Hamilton, 1822)	Plentiful Plentiful	MD, HA, GRC, GC GRC
Muraenidae	Maoray eel	Threatened	MD, HA

Haji-Ali shore: There were a total of 30 species of macrobenthos observed during the surveys. The shores of this area were dominated by gastropods with seven genera, four species of bivalve, and in some regions dense population of sea anemones. The sea shore of Haji-Ali is dominated by *Euchelus asper* (17-42%) followed by *Bursa tuberculata* (9-22%) and *Trochus radius* (5-21%). There was a unique presence of the bivalve *Gastrena polygona* recorded here. *G. polygona* was not detected at any other intertidal area of the Mumbai shore. *G. polygona* was found in the muddy substratum in the Middle and Lower zone. During low tide, the long red siphon of *G. polygona* was found to sprinkle water – an activity that was used to find its location. Also present in significant numbers were the edible bivalve *G. divaricatum*, *Dosinia gibba* and *Crassostrea cucullata*.

Gorai Creek shore: In Gorai Creek five algal species were rarely sampled. Species of *Sargassum*, *Gracilaria*, *Ulva*, *Entermorpha* and *Chaetomorpha* were detected here, although their density was limited. All the species were found in a healthy condition with respect to coloration and condition of leaves. In the mudd of Gorai shore, were registered high densities of *Boleophthalmus*, mainly *B. boddaerti* and *B. viridis*. Alongside this, mainly molluscs and arthropods were recorded in Gorai Creek. Among the gastropods present, *Telescopium telescopium* and *P. cingulata* were found abundantly. In comparison with these gastropods, the occurrence of bivalve species was uneven and less dense. *Venerupsis microphylla* species was sampled and registered for the first time in the shore sectors of the creek. Arthropod fauna was identified mainly as crustaceans which included crabs from 14 species and 10 genera. Among the crabs, the fiddler or dhobi crabs of three species were found abundantly in marshy places in mangrove swamps. During ebb tides these crabs were seen to swarm out from their burrows. *Thalamita crenata* was found infrequently. A family Grapsidae species was sampled plentifully in human-made structures of stone and craks in wooden elements of a bridge.

Many previous investigators assessed the biodiversity of east and west coasts of India from time to time. Biodiversity patterns monitoring of the Indian coast is missing and complete data about biota dispersion for numerous areas of Indian coast is not available. Abercrombie (1892) and Melvill and Standen (1910) had assessed molluscan diversity of gastropods and bivalves at intertidal areas of the Bombay Presidency. Chhapgar (1957, 1958) had studied status of crabs from intertidal areas in Bombay. The National Institute of Oceanography (NIO) achieved out the first complete assessment of the Uran coast in 1986. Likewise Babu (1999) researched mangroves and associated fauna of the Uran coast area. Given this data incoherency and inconsistency, the data given in this research of macro-benthic fauna can represent a base line for future comparisons.

Bhatt (1959) has reported twenty four species of algae, two species of sponges, forty three species of crabs, six species of *Balanus*, fifty nine species of gastropod and thirty one species of bivalve from various shore areas of Mumbai. Shore areas monitored by Bhattt (1959) includes Cuffe Parade, the Secretariat foreshore, Chowpatty Sand, Chowpatty Rocks, Breach candy, Dadar and Mahim. The areas between Haji Ali and Worli have not been surveyed. Other lotic systems like Gorai in Mumbai have not been researched for macrobenthos. Therefore the base line data on macrobenthos in these areas are not available. Furthermore, Bhatt (1959) recorded twenty four species of algae but during the present investigation only ten species of algae were detected in Gorai Creek. The reduction in number of algal species noted clearly indicates anthropogenic pressure on this fragile community. Except for species of *Caulerpa* and *Dictyota*, brown alga and other species were not found abundantly in these areas.

The gastropod species of *Planaxis sulcatu*, *Bursa tuberculata*, *B. spinosa*, *B. granulose*, *Nerita oryzarum*, *Natica maculosa* and others given in table 1 were reported in earlier studies of the shore areas of Mumbai (Bhatt, 1959; Jaiswar, 1999). However, the regular presence of these gastropods at the study sites suggests that they have adapted well to the changes in environmental conditions, as the earlier studies indicate them to be rare or missing. During the present investigation, the bivalve *Gastrana polygona* was detected only at Haji-Ali and presence of this clam was not reported by Bhatt (1959). Jaiswar and Kulkarni (2005) also noted a rare occurrence of *G. polygona*. Further presence of oysters at rocky shore of Worli indicates suitability of the shore for oyster growth. *Crassostrea gryphoides* was found by Bhatt (1959) and Jaiswar and Kulkarni (2005). But during the present investigation, *C. gryphiodes* was mainly detected in higher densities in the middle part of the rocky shore. Seven species of crabs recorded on the Worli shore also suggest that the rocky shore here is helpful in providing a habitat for these crabs. Rocks and boulders in the area create crevices and other hiding place for the crabs.

The presence of three species of *Antedon* (feather star) and one species of *Echinus* (*Temnopleurus toreumaticus*) is a unique diversity characteristic observed near Mumbai coastal waters. Until now, no one has reported the presence of such number of echinoderms in and around the Mumbai shore (NIO, 1986). Jaiswar and Kulkarni (2005) reported sporadic distributions of *Placenta placenta* in shore waters of Mumbai, although the effects of pollution on *P. placenta* have been reported by Jaiswar (1999). The crabs recorded here were also reported by Chhapgar (1957). Further, Subrhmnyam et al. (1952) had reported gastropods and bivalves in intertidal areas of Mumbai. But during the present investigation, species diversity of molluscs was observed to have declines in comparison with earlier studies. The obvious existence of pollution sources indicates the effect of human pressures on shore in the Mumbai city area.

CONCLUSIONS

This study has provided a first baseline of intertidal macrobenthic species in the Mumbai area. It indicates that intertidal macrobenthic species are declining, and threatened by increasing human pressures on this habitat. In conclusion it is necessary to have in deep survey of whole Mumbai and nearby shore areas for a more accurate knowledge of the biodiversity status of the area, and to permit ongoing monitoring of the situation. It will also be important to take steps to address ongoing issues such as the release of untreated waste water from domestic and industrial sources, if macrobenthic species and habitats are to recover.

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THE STATUS OF *ROMANOGOBIO URANOSCOPUS* (AGASSIZ, 1828) SPECIES, IN MARAMUREŞ MOUNTAINS NATURE PARK (ROMANIA)

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DOI: 10.1515/trser-2017-0007

KEYWORDS: Danubian longbarbel gudgeon, habitats, human impact, assessment.

ABSTRACT

The condition of aquatic habitats typically occupied by *Romanogobio uranoscopus* within the Maramureş Mountains Natural Park fluctuates, in the best cases, between reduced to average. Good or excellent conservation status is now absent for populations of this species in the researched area. The identified human impact types (poaching, minor riverbeds morphodynamic changes, solid and liquid natural flow changes, destruction of the riparian vegetation and bush vegetation, habitat fragmentation/isolation of population, organic and mining pollution and displaced fish that are washed away during the periodic flooding in the lotic sectors uniformized by humans) are contributing to the diminished ecological state of *Romanogobio uranoscopus* habitats and for that reason populations. *Romanogobio uranoscopus* is now considered a rare species in the studied basin but where this species was specified as missing, it has been registered with a restorative potential.

RESUMEN: El estado de *Romanogobio uranoscopus* (Agassiz, 1828) en el Parque Natural Montañas Maramureş (Rumania).

La condición de los hábitats acuáticos que típicamente ocupa *Romanogobio uranoscopus* dentro del Parque Natyural Montañas Maramures fluctúa, en el mejor de los casos, entre degradado y promedio. Los estados excelente o bueno no existen para las poblaciones de esta especie en el área de estudio. Se categorizaron distintos tipos de impacto humano (pesca ilegal, cambios morfodinámicos menores en los ríos, cambios en el flujo natural de líquidos y sólidos, destrucción de vegetación arbustiva y de árboles riparios, aislamiento/fragmentación del hábitat de la población, contaminación orgánica y de minería y desplazamiento de peces que son arrastrados en los periodos de inundación hacia sectores lóticos homogeneizados por el humano) que contribuyen a empeorar el estado ecológico de los hábitats de *Romanogobio uranoscopus* y, por consiguiente, de sus poblaciones. *Romanogobio uranoscopus* puede ser considerada actualmente como una especie rara en el cuenca estudiada, que si bien ha desaparecido de algunos sectores, aún existe potencial de restauración.

REZUMAT: Starea de conservare a speciei *Romanogobio uranoscopus* (Agassiz, 1828), în Parcul Natural Munţii Maramureşului (România).

Calitatea habitatelor acvatice ocupate de regulă de *Romanogobio uranoscopus* în Parcul Natural Munții Maramureșului variază între scăzută și medie, în cele mai bune cazuri. Starea de conservare a populațiilor acestei specii în zona investigată variază între moderată și slabă. Categoriile de impact antropic identificate (braconaj, modificări în morfodinamica albiilor minore, modificări de debit natural solid și lichid, distrugerea arboretelor ripariene și a vegetației arbustive, fragmentarea habitatelor/izolarea populațiilor, poluare organică și minieră) contribuie la deteriorarea stării ecologice a habitatelor speciei *Romanogobio uranoscopus* și la declinul populațiilor sale. Specia poate fi considerată în prezent ca specie rară în bazinul studiat, dar există potențial restaurativ pentru mai multe sectoare de râu.

INTRODUCTION

The condition of the highland water natural sources are generally influenced by low anthropic activities (Curtean-Bănăduc and Bănăduc, 2012; Romanescu, 2016), which should be evaluated in a specific area background.

The lotic systems of the Maramureș Mountains Nature Park area consist mostly of the Vișeu Basin (Fig. 1) and a few little streams, of the Bistrița Aurie Basin, in the northern side of the Romanian national territory. This basin is neighboured by the Maramureș Mountains in the northeast, the Rodna Mountains in the south, and the Maramureș Hills in the west and southwest. The lowest sector of the studied watershed is at 303 m above sea level at the junction of the Vișeu and Tisa rivers. The highest sector is at 2,303 m altitude in the Pietrosul Rodnei Peak in the Rodna Mountains. Due to the geological and the relief variety within this watershed (glacial relief forms, karst, exokarst, and so forth), the studied basin is various in scenery, with a great diversification of biotopes, biocoenosis, including ichthyocoenosis. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

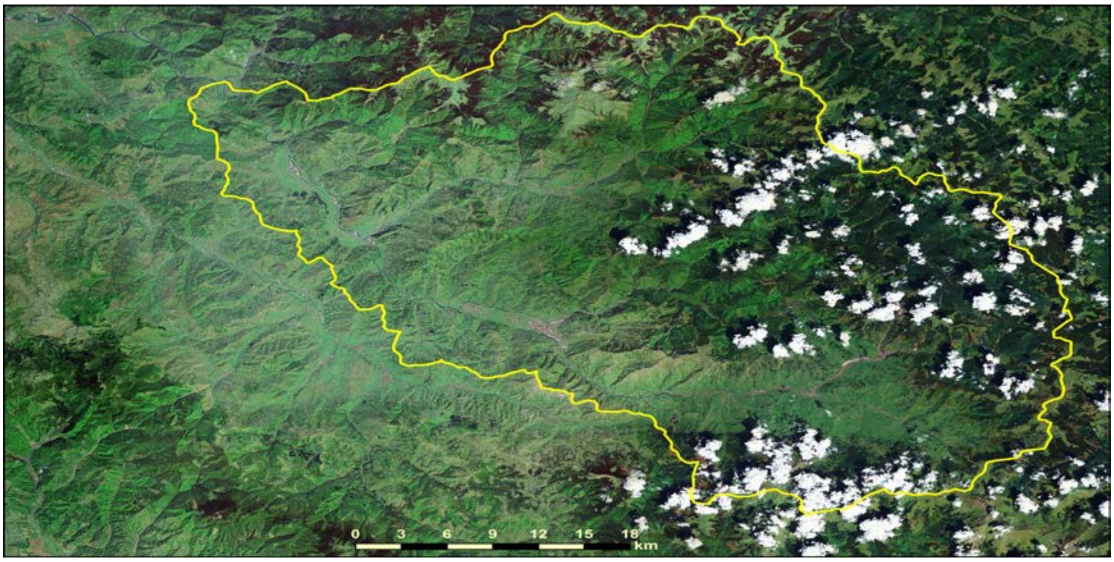

Figure 1: Vișeu River basin; GIS support Danci O.

The Vișeu River is one of the main tributary of the Danube River, entering into the much larger Tisa River. It is over 80 km long and has a multiannual average discharge of 30.7 m^3/s at its lower sector near the junction with the Tisa River. The springs are situated in the Prislop Pass (1,416 m) area and it flows into the Tisa River, in the proximity of Valea Vișeului locality, the watershed covers 1,606 km^2. In its higher area, from its springs to the Moisei locality, the Vișeu River has a considerable declination (20-50 m/km) having as a name Vișeuț or Borșa. The Vișeu River at Moisei locality drains into the Maramureș Depression where its valley is wider, in spite of the presence of few narrow gorge-like corridors: Rădeasa Gorges between Moisei and Vișeu de Sus, Oblaz Gorges between Vișeu de Jos and Leordina, and Vișeu Gorges between Bistra and Vișeului Valley. The hydrography of Vișeu River is of Eastern-Carpathian-Moldavian type in the upper part and of Eastern-Carpathian-Transylvanian type in its lower sector. Its flow is important in the spring (39.4% of the annual flow), later diminishing in the summer (27% of the annual flow), further diminishing during the autumn (18.6% of the annual flow), with its minimum period during winter (15% of the annual flow). (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

Because the Vişeu Watershed is located, for the largest part, in mountainous areas (67%) there is also an important density of the hydrographic network (0.7-1 km/km^2) and one of the highest specific flows in the Eastern Carpathians, as a consequence of rain and snow of over 1,100 mm/year. In the Vişeu River upper part, its tributaries start in the glacial Rodna Mountains, with a flow of around five m^3/s. The most important Rodna-originating tributaries of Vişeu are the following: Fântânilor Valley (seven km in length), Negoiasa Valley (six km), Repedea Valley (10 km), Pietroasa Valley (seven km), Vremeșu Valley, Hotarului Stream, Dragoș's Valley (11 km) and Izvorul Negru (seven km). The most important Maramureş Mountains right side tributaries are: Hășmașul Mic, Cercănel (11 km), Țâșla (20 km), Vaser (52 km in length and catchment area of 422 km^2, with an average flow of nine m^3/s contributing 27% to the total flow of Vişeu), Novăț (16 km, 88 km^2 tributary of the Vaser), Ruscova (39 km in length and 435 km^2 catchment area, average discharge of 11.3 m^3/s), Socolău (13 km in length and 72 km^2 catchment area, tributary of the Ruscova), Repedea (19 km in length and 87 km^2 catchment area, tributary of the Ruscova), Bardi (11 km in length and 32 km^2 catchment area, tributary of the Ruscova), Covașnița (11 km in length and 34 km^2 catchment area, tributary of the Ruscova), Frumușeaua (14 km in length) and Bistra (nine km in length). The left-side tributaries spring from the Maramureș Hills area, which are relatively small with low water input: Drăguiasa, Cocicoi, Spinului, Plăiuț, Neagră and Luhei. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

In the Vişeu River basin, the water characteristics are influenced in some areas by the presence of mineral springs (approximately five in Maramureş Hills; approximately six in Rodnei Mountains, and 150 in Maramureş Mountains) with appreciably various composition (bicarbonate, ferrous, sulphurous and saline) (Curtean-Bănăduc et al., 2008).

In the Rodnei and Maramureş Mountains the lotic systems are sometimes "blocked" by sizable waterfalls and series of rapids, we note such large waterfalls from the Rodnei Mountains: Cailor, Cimpoioasa, Repedea and Izvorul Verde; and from the Maramureş Mountains: Criva, Tomnatic and Bardău. Stagnant water systems also materialize. Glacial lakes from Rodnei Mountains are situated at an altitude over 1,900-1,950 m and were formed at the heels of some deposits like the following: Gropi Lake, Iezer Lake, Rebra Lake, Buhăiescu Lake, Cimpoieş Lake and Negoiescu Lake. The wetlands (marshes) of the studied area are eutrophic and oligotrophic: Tăul Obcioarei, Strungi, Jneapănul Hânchii, Tăul Ihoasa, Tăul Băiţii, Pietrosul Barcăului, Vârtopul Mare, Preluca Meşghii, Tăul cu Muşchi and Bedreasca. The lakes in the Maramureş Mountains area are Bârsănescu, Lutoasa, Budescul Mare, Vinderel and Măgurii. Near Petrova locality in the Vişeu Valley, there are a few small bodies of water (ponds). (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

The mixture of aquatic and semi-aquatic habitats and their related endangered, rare and endemic species from Vişeu Basin are diversified and very precious under conservation perspective. The fish species of the studied area are not exceptions in these circumstances, as noted by many ichthyologists for over a century in particular studies (Bănărescu, 1964; Staicu et al., 1998; Curtean-Bănăduc et al., 2008). Over 50% of the local fish species are of important conservation value.

Romanogobio uranoscopus (Assiz, 1828) is one of these fish species of conservation value (Bănăduc, 2007), populations within the Vişeu River basin have significantly diminished. Actual distribution and abundances of these valuable taxa are not completely known and specific targeted data for an optimum management is highly necessary.

MATERIAL AND METHODS

Study on populations of *Romanogobio uranoscopus* within the Maramureş Mountains Natural Park was done in 2007-2015, consisting of 370 sampling sectors (Fig. 2; Tab. 1). This study included population mapping, assessment of the actual conservation status, and description of the elements culpable for the actual diminishing of populations.

The study starts from the working hypothesis (a) and null hypothesis (b): 1a. Aquatic habits with reduced conditions will have smaller populations of *R. uranoscopus*; 1b. There will be no difference in *R. uranoscopus* populations between habitats of reduced or average condition; 2a. The population of R. uranoscopus has declined over the period 2007-2015; the population of *R. uranoscopus* has not declined over the period 2007-2015.

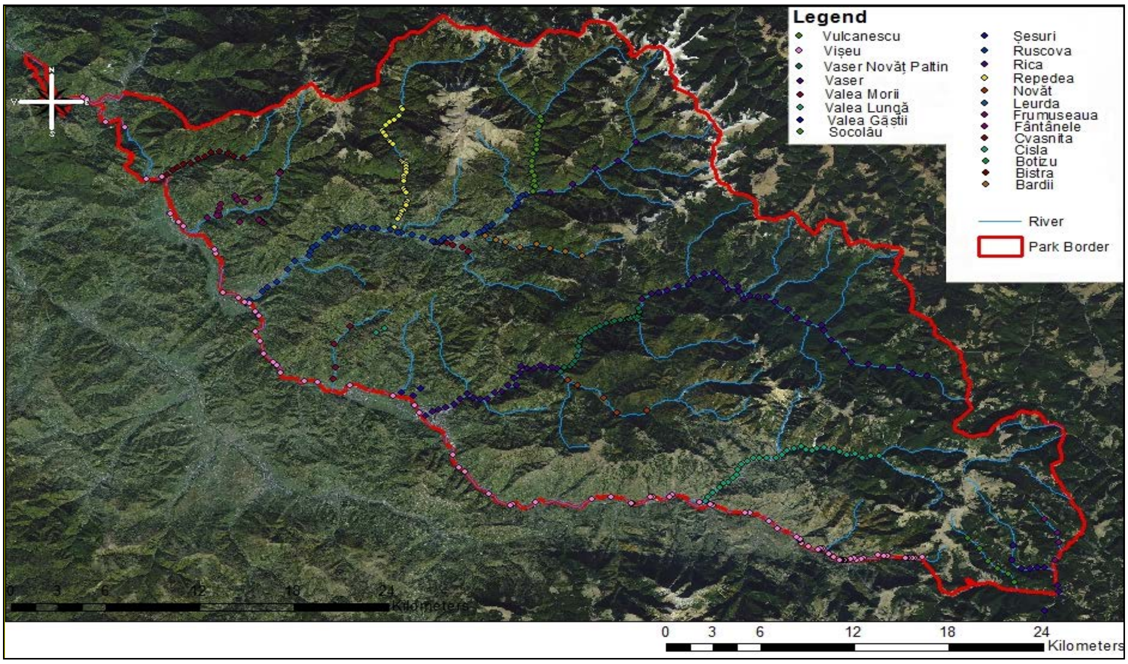

Figure 2: Locations of the 370 sampling stations; GIS support Danci O.

To assess the status and population of *Romanogobio uranoscopus* within the Maramureşului Mountains Nature Park, quantitative samples were collected from sampling stations within a range of three kilometres between two successive sectors on all habitats with proper conditions for this fish species. The positions of the sampling stations allow the assessment of the consequence of anthropic impact on the studied fish populations, containing the biotope state change, presence of riverbed exploitation, hydrotechnical works, pollution sources, uncontrolled sport fishing and heavy poaching.

Ichthyofauna quantitative sampling was realized by the electronarcosis, per unit of time and effort per each section (two hours on Vişeu River, one hour on Ruscova River, 30 minutes on the other rivers of the studied zone), on five longitudinal sectors of 100 m length. After the fish species identification, all fish were right away released in their habitat.

The number of fish sampled in the time/effort unit can be transformed by correlation in classes: (C) – common fish species, (R) – rare fish species, or (V) – very rare fish species, alike the guidelines for Natura 2000 standard data form filling, "In mammals, amphibians, reptiles and fishes, no numeric information can be indicative and then the size/density of the population is evaluated as (C) – common species, (R) – rare species, or (V) – very rare species".

The criteria used to assess the population status are: population size, balanced distribution of individuals by age classes, areal size and the percent of fish individuals of the species of interest in the structure of fish communities.

Similar to the Natura 2000 guidance, standard data form filling the following criteria "The conservation degree of specific habitats" contain subcriteria: i) the degree of conservation of the habitat features which are important for the species; ii) possibilities for recovery.

The criterion i) needs a complete evaluation of the characteristics of the habitat regarding the necessities of the species of interest. "The best expertise" is used to rank these criteria in the following way: I. elements in excellent condition, II. well preserved elements, III. elements in average or partially degraded condition.

In the circumstances in which the subclass I is granted "I: elements in excellent condition" or "II: well preserved elements," the criteria B (b) should be grouped as "A: excellent conservation" or "B: good conservation", unconcerned of the other sub-criteria.

In the case of this sub-criterion ii) which is taken into account only if the items are moderately or fractionally deteriorated, an assessment of the viability of the studied population is needed. The acquired classification system is: I. easy recovery; II. restoration possible with moderate effort; III. restoration problematic or impossible.

The combined practice for categorization relies on two sub-criteria: A – excellent conservation = elements in excellent condition, regardless of classification of recovery possibility; B – good conservation = elements in average or partially degraded condition and easy to restore; C – average or reduced conservation = all other combinations.

In all sampled areas, the following were assessed: condition, pressures/threats of habitats and populations of interested fish species.

The sampling sections to assess fish population and the conservation status of *Romanogobio uranoscopus* in the studied area appeared in sectors where these populations are stable, with a favoring conservation status and well maintained typical habitats, as well as lotic sectors placed at the boundary of the distribution area for this fish species, which contain sectors under human activities impact that can put in jeopardy the studied populations status – the Representativity Criteria.

We based on the economical criterion for selecting the monitoring sectors; as well an average number was set to offer the data for the management instruments which should assure the conservation of a favourable status for the studied fish species in the researched area.

Romanogobio uranoscopus (Agassiz, 1828), Actinopterygii – Cypriniformes – Cyprinidae – Gobioninae (Fig. 4), was sampled in the studied area in the last century (Bănărescu, 1964; Staicu et al., 1998; Telcean and Bănărescu, 2002; Homei, 1963).

This fish body and the caudal peduncule are thick and cylindrical. At the lips, points unite in a posteriour extension which is like a second pair of whiskers. The anus is closer to the anal fin than the ventral fins. The chest is coated with scales. In Romania lives *Romanogobio uranoscopus* (Agassiz, 1828). The dorsal contour is slightly convex, the ventral is horizontal. The snout is approximately sharp. The eyes look upward. The fish ventral fins are inserted under the dorsal fin insertion or slightly backward. The caudal fin is profoundly holed; the lobes are rounded and equal or almost equal (the inferior lobe a little longer). The outline of the dorsal fin is slightly holed. The dorsal side is greyish-greenish or brown-reddish. The back scales have black margins. Behind the dorsal fin are two-three big dark marks. There are seven-ten big rounded marks on the flanks. The ventral side is white-yellowish. There are two white marks at the caudal fin base. There are two rows of black marks on the dorsal and caudal fins. It can reach a total of 13 cm length. (Bănărescu, 1964; Bănărescu and Bănăduc, 2007)

RESULTS

The river sectors where *Romanogobio uranoscopus* (Fig. 3) was sampled during the study are presented in table 1 (Fig. 4), for all such sectors the catch index values were presented (individual numbers per time and effort unit).

Figure 3: *Romanogobio uranoscopus* (Agassiz, 1828).

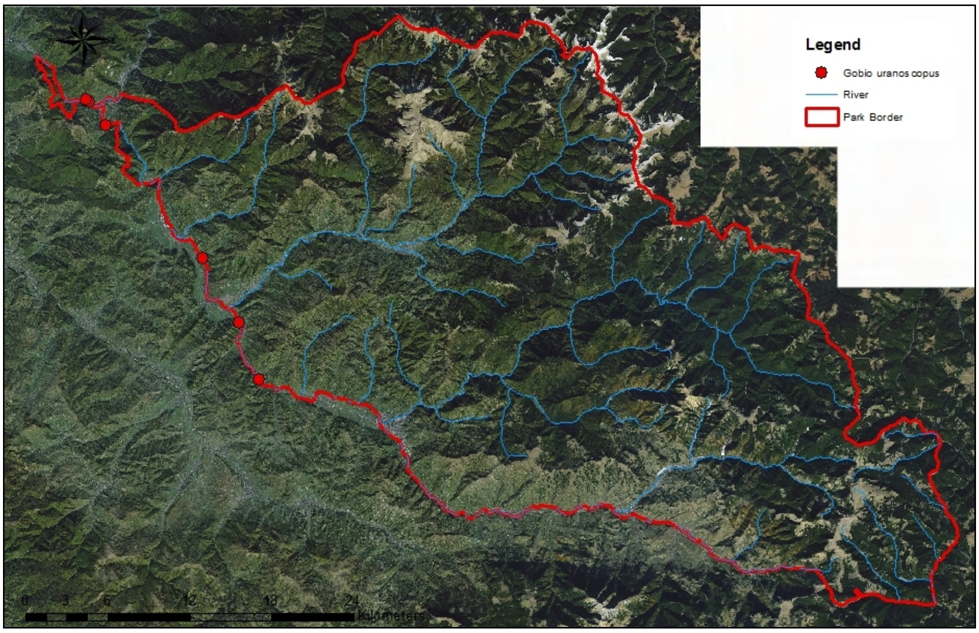

Figure 4: *Romanogobio uranoscopus* sampling stations location; GIS support Danci O.

Table 1: *Romanogobio uranoscopus* sampling points in the study area.

No. crt.	Lotic system	Station code	Lat. (N')	Long. (E')	Catch index no. ind./100 m × 30 min	Characteristic habitat state
1.	Vișeu River	57	47 44 17.0	24 18 12.0	1	reduced
2.	Vișeu River	63	47 46 29.5	24 17 03.1	1	reduced
3.	Vișeu River	690	47 48 54.3	24 14 49.6	1	reduced
4.	Vișeu River	77	47 53 59.9	24 09 07.1	7	average
5.	Vișeu River	78	47 54 52.5	24 08 07.8	18	average
6.	Vișeu River	79	47 54 58.3	24 07 56.5	1	average

DISCUSSION

Based on the outcome of this study, consistent with *Romanogobio uranoscopus* fish species biological and ecological needs, there were identified some risk elements (pressures and threats): poaching, minor riverbed morphodynamic changes, liquid and solid natural flow disruption, habitats/fish populations fragmentation, pollution.

Poaching. During the study period poaching was noticed with electricity from different rechargeable gears. Poachers were found during their illegal fishing activities including using different substances to collect fish of any size. By asking many people who live in study area, poaching is a relatively uninterrupted activity around the year. The failure to control this local habit may reduce the number of *Romanogobio uranoscopus* individuals and diminish its distribution in the Vişeu Basin.

Minor riverbed morphodynamic changings. Typical diversified microhabitat and habitat needs of this fish species, in consonance with its life cycle phases, it contains natural riverbed morphodynamics variability. Dams, dikes, sills, roads in riverbeds, modified riverbeds, riverbed mineral exploitation (Fig. 5), influence the dynamics of liquids and solids flow, etc., all influencing through changing the natural morphodynamics of the riverbed. These modifications changed the habitats needed for different life cycle phases of the *Romanogobio uranoscopus*, which could push to decline the abundance of this fish species population.

Watercourse obstacles, water resource development activities growth on the studied area (dikes, dams, high sills, microhydropowerplants, water extractions, modifications in the riverbeds, riverbed mineral overexploitations, etc.) should not be allowed by the Park Administration without explicit ichthyologic applied studies for this valuable fish species.

Figure 5: Overexploitation of minerals in the banks and terraces of the lower Vișeu River.

Solid and liquid and natural flow changings. The modifications of natural liquid and solid flow and riverine morphology change the generation of particular microhabitats, habitats, and other environmental elements important for the presence of *Romanogobio uranoscopus*. These modifications to the riverbed natural morphodynamics may induce the decreasing of the studied species population size. Unnatural artificially episodes (Fig. 6), where water turbidity is raised due to bad forestry activities near the riverbeds, there are cases of activities inducing negative effects on the natural regime of the river solid and liquid flow.

The natural discharge can be avoided if the riverbed mineral exploitations and/or forestry practices do not disturb considerably the basin limits of self-sustainable function. This can be realised by harmonizing the human activities within the seasons of the year when the natural conditions are relatively similar to those to be produced (e.g. high water turbidity). Potential planned in-channel constructions and changes, such as dams, thresholds, water extractions, bank modifications and roads in the waterbed (Fig. 7), crossings, embankments, thalweg changes by exploitations of construction materials from the riverbed, etc., should be not admitted by the protected site administrator without the consent of experts with a proper expertise for this fish species, based on the identified local stress elements and the ecological and biological needs of the fish species of conservation interest. In this distinct case, no riverbed overpass should be higher than 5-10 cm in the shallow water lotic sectors and in dry season. The authors suggested also the monitoring the banning of dragging and storage lumber through/in the streams and rivers. The authors suggest the control of the development works for lumber storage and exploitation terraces, (Fig. 8) and the imperative requirement of fast reforestation. In this case, the rotation of forest exploitations in the sub-basins of the Vișeu Basin is more than advantageous.

Figure 6: Forestry activities induce unnatural turbidity (Vişeu and Sârca tributary confluence).

Figure 7: Frumuşeaua River concrete riverbank/completely modified and road in the riverbed.


Figure 8: Logs transported on the Vaser River banks and in the riverbed.


Figure 9: Destroyed riparian vegetation on the Ruscova River bank.

Habitat fragmentation/isolation of populations very often push to genetic isolation, decline of gene variability and, to species inbreeding and sometimes local or regional extinction. Dams disconnect rivers into sections, which limit Danubian longbarbel gudgeon access to old spawning habitats, are one of the most serious causes of habitat degradation resulting in the decreased abundance and disappearance of this species (Bănărescu, 1964). Dams can also put not direct pressures on the Danubian longbarbel gudgeon populations by inducing modifications in water thermal regimes, blocking the transport of the organic and inorganic materials, altering water flow and by sediment accumulation.

The free upstream and downstream displacement, including the various sub-drainage basins of the Vișeu catchment area, is a highly important element for the studied fish species protection and conservation.

We propose the study of the potential future economic investments located near and/or on the water courses very laboriously, as far as some of them could decrease or completely cut the longitudinal connectivity of the rivers and/or streams of the studied basin, not only by constructing diverse traverse barriers in the riverbed, but also by lowering the water level or, sometimes, preventing water from accessing some lotic sectors.

Pollution caused by mining activities. The very old documented pollution, occurring from heavy metals mining activity in the Țâșla Basin, is affecting negatively not only the Țâșla River, but also the upstream part of Vișeu River (Staicu et al., 1998). The impact of the rainfall and snowfall washing waters of the non-isolated mines and greened refuse heaps is considered as major on the Țâșla River and significant on the upstream Vișeu.

The impact of rainfall and snowfall water washing the non-isolated mines and rehabilitated refuse heaps can be significantly reduced by isolating/filling the old mine galleries and by isolating (not only greening) the refused heaps from the water courses in the Țâșla River basin.

Obviously, the synergism among the identified human impact put pressure on numerous lotic sectors in the researched area (Figs. 10 and 11) and the evaluation score for the reserached fish species is not at the natural potential.

Organic pollution caused by sewages, agriculture and fish farms, resulted in disappearance of Danubian longbarbel gudgeon from some historic spawning habitats. It is a significant problem related to sewage and wastewater treatment as well as to the farms, in the large majority of the Vișeu Basin, mainly on the Vișeu River, this is a continuous impact source for the studied fish species.

Exhaustive sewage systems must be realised first in the Vișeu River basin and lately on its tributaries basins, also the wastewaters of the localities alongside the main tributaries must be cleaned.

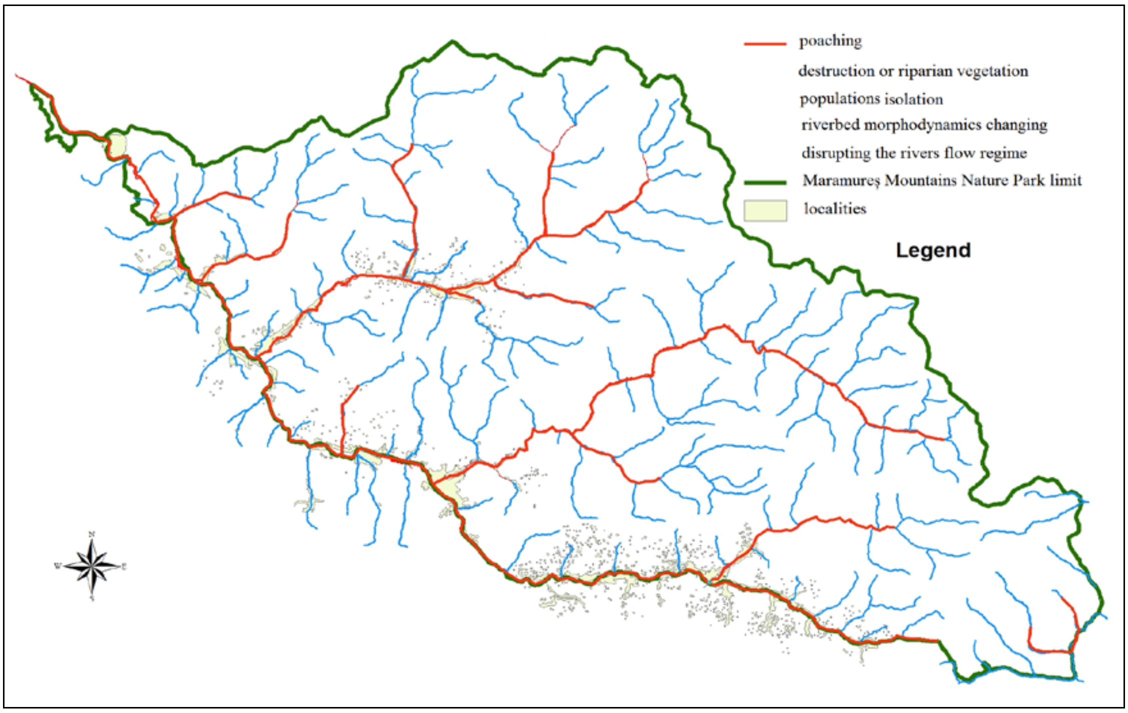

Figure 10: Diagnosed combined pressures and threats
for *Romanogobio uranoscopus* in the studied area; GIS support Danci O.

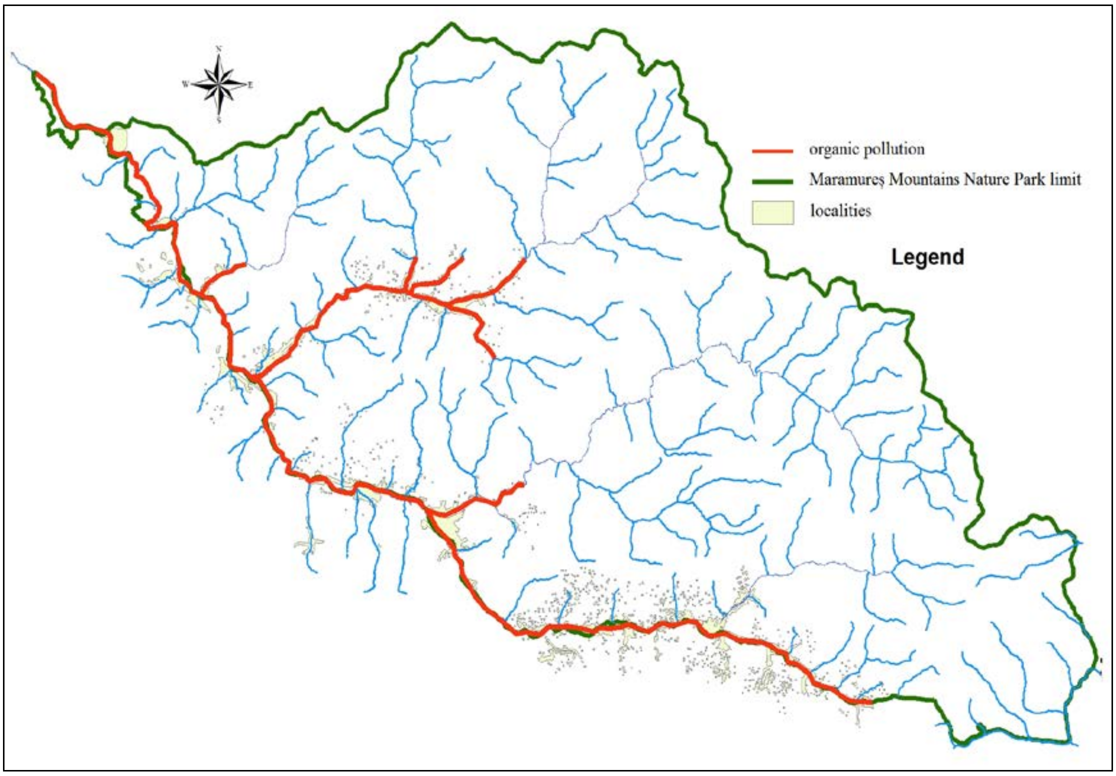

Figure 11: Lotic sectors influenced by organic pollution; GIS support Danci O.

CONCLUSIONS

Romanogobio uranoscopus (Agassiz, 1828) is one of the fish species of important conservation concern within the Vişeu River basin, one of the remote areas of northern Romania. The condition of aquatic habitats typically occupied by *Romanogobio uranoscopus* within the Maramureş Mountains Nature Park fluctuates in the best cases between reduced (half of the lotic sectors where the species was identified) to average (half of the lotic sectors where the species was identified). Good or excellent conservation status is now missing for populations of this species in the studied area.

The determined human impact types (poaching, minor riverbeds morphodynamic changings, solid and liquid natural flow changes, destruction of riparian trees and bush vegetation, habitat fragmentation/isolation of population, organic and mining pollution, and displaced fish that are washed away during flood periods in the lotic sectors uniformized by humans) are inducing the decreasing ecologic state of *Romanogobio uranoscopus* species habitats and as a result the populations in the researched area in comparison with its natural potential are significantly below the potential in natural conditions.

Romanogobio uranoscopus has constant populations in the researched area, but their natural potential in comparison with historical data due to human impact is not realised in terms of aquatic habitat and abundance of individuals, in the Vișeu – middle and lower sectors. The preferred habitat for this species is big enough within this area to conserve the present reduced to average ecological state of the Danubian longbarbel gudgeon researched populations.

Romanogobio uranoscopus can be considered today as a rather rare species in the studied basin but there, where a specific absence of this species was registered, exists a restorative potential (middle and upper Vișeu River and at least Ruscova and Vaser lower sectors).

ACKNOWLEDGEMENTS

These data were obtained in the project "Inventarierea, cartarea și evaluarea stării de conservare a speciilor de pești din Parcul Natural Munții Maramureșului (ROSCI 0124 Munții Maramureșului)/Inventory, mapping and assessment of the conservation status of fish species of Munții Maramureșului Nature Park (ROSCI 0124 Maramureșului Mountains)". Thanks for the GIS support to Ms. Danci O. Special thanks for the continuous support of the Munții Maramureșului Natural Park Administration and Scientific Council members especially to: Bogdan C., Bucur C., Szabo B., Brener A. and Mărginean M.

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DISAMBIGUATING PRAXIS FROM PRACTICE IN NATURAL RESOURCE MANAGEMENT: A PRACTICAL SPACE FOR ENHANCING EXPERIENTIAL LEARNING IN THE EASTERN COAST OF TANZANIA

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DOI: 10.1515/trser-2017-0008

KEYWORDS: Praxis, Practice, Natural resource management, Experiential Learning.

ABSTRACT

It is evident that practice and praxis have significantly contributed to knowledge generation in the Tanzanian coastal belt, especially where Integrated Coastal Management (ICM) programmes have been adopted and practiced such as Tanga, Dar es Salaam, Mtwara, Lindi, and the Coastal region (KICAMP, 2001; NICEMS, 2003). In spite of such learning evidences, users of generated natural resource data in the coastal area tend to employ *practice* and *praxis interchangeably*, conflating the two concepts together; leading to a situation where one may hardly ascribe generated knowledge appropriately to contexts that favour occurrence of each of the two constructs. The paper adopts ethnographic approach in a defined coastal case study to examine contexts and situations that signals “conflation” and it employs examples that may help readers of the article to disambiguate praxis from practice.

RESUME: La différence entre expérience et pratique dans la gestion des ressources naturelles: un espace pratique pour l’amélioration de l’apprentissage expérientiel sur la côte est de la Tanzanie.

Il est évident que la pratique et l’expérience ont contribué de manière signifiante à la génération du savoir dans la région côtière de la Tanzanie, particulièrement là où ont été adoptés et mis en pratique lesprogrammes de Gestion Intégrée des Côtes (ICM) tels que Tanga, Dar es Salaam, Mtwara, Lindi et la Région Côtière (KICAMP, 2001; NICEMS, 2003). En dépit des preuves d’apprentissage, les usagers des données générées sur les ressources naturelles dans les régions côtières ont tendance à alterner entre *pratique* et *expérience*, confondant les deux concepts et menant à une situation où on peut à peine attribuer le savoir généré de manière appropriée aux contextes favorisant l’occurrence de chacune des deux expressions. L’article adopte l’approche ethnographique dans une étude de cas défini côtier afin d’examiner les contextes et les situations signalant “l’amalgame” et il utilise des exemples afin d’aider les lecteurs de l’article à faire la distinction entre l’expérience et la pratique.

REZUMAT: Diferența între experiență și practică în managementul resurselor naturale: un spațiu practic pentru ameliorarea învățării experiențiale pe coasta de est a Tanzaniei.

Este evident că practica și experiența au contribuit semnificativ la generarea de cunoaștere în centura de coastă a Tanzaniei, în special acolo unde au fost adoptate și implementate programe de Management Costier Integrat (MCI), ca de exemplu în Tanga, Dar es Salaam, Mtwara, Lindi și Regiunea Costieră (KICAMP, 2001; NICEMS, 2003). În ciuda acestor dovezi de învățare, utilizatorii de date generate despre resursele naturale în zona de coastă tind să utilizeze *practica* și *experiența interșanjabil*, confundând cele două concepte, ceea ce conduce la o situație căreia cu greu i se poate atribui generarea de cunoștințe în mod corespunzător contextelor. Articolul adoptă o abordare etnografică într-un studiu de caz costier definit pentru a examina contexte și situații care semnalează „amalgamul” și folosește exemple ce pot ajuta cititorii articolului să facă deosebirea între experiență și practică.

INTRODUCTION

This journal article examines the features that distinguish practice from praxis. The argument is illustrated with examples from a natural resource management context in the coastal belt of Tanzania. It addresses two research questions: 1. What is the theoretical distinction between praxis and practice in the natural resource management context? 2. How can researchers and users of natural resource knowledge avoid collapsing praxis to practice in the experiential learning space?

While both *praxis* and *practice* involve actions, the former has some special attributes that differentiate it from the latter. In this paper, praxis is defined as a moral action that follows the logical nature of an intervention and safeguards or benefits the community at large (Kemmis and Smith, 2008). By contrast, practice may or may not be a moral act. Furthermore, if it is a moral act, its morality is not derived from the logic of the intervention, neither does it necessarily benefit the community at large. It may, for example, be a moral act based on fideism (what is good is what an authority figure tells us) or history (what is good is what we have always done in the past). From these definitions, it may be argued that, since *praxis* carries community interests on board, it always involves more than one individual. However, this may not be the case for practice. In the context of the coast of Tanzania, examples of the practice/praxis divide are common among the different stakeholders involved in the community and institutions involved in Integrated Coastal Management (ICM). The constructs of practice and praxis are often-times mistaken by users of coastal data and information as carrying the same meaning; a situation that attracts confusion and misappropriation of knowledge that is generated from practice and praxis contexts.

This journal article brings examines contexts and situations that signals the "conflation" of praxis and practice and employs examples that may help readers of the article to disambiguate praxis from practice in the coastal resource management context. This can help researchers and users of coastal resources to avoid collapsing praxis to practice in the experiential learning space.

METHODS

What follows is a brief summary of the materials and methods used in this research. Data generation was pursued through primary and secondary data sources in a case study research context which sought to gain profound insight into on-going coastal-based practices and praxis in a coastal mangrove strip that extends from Moa to Boma localities in Mkinga District (a new district in Tanga Region, North Eastern part of Tanzania).

Case study research can reveal rich insight about the case that is being studied (Yin, 2012) and can help researchers to "retain holistic and meaningful characteristics of real-life events" (Yin, 2003). This study pursued a "descriptive case", which according to Yin (2012) offers "rich and revealing insights into the social world of a particular case".

Primary data generation involved open observation of ongoing coastal practices and praxis and in-depth face-to-face interviews with a total of 10 mangrove restorers, four mangrove-based fishers and eight elders who have lived in the study area for over 10 years. These were selected strategically based on the criteria of their direct involvement in coastal-based practice and praxis. The use of strategic or purposive sample in this case is based on the fact that the study intended to investigate coastal based praxis and practice. As Teddie and Yu (2007) put it, this kind of sampling is applied "when the individual case itself or a specific group cases is a major focus of the investigation".

Secondary data generation involved the use of both existing literature (books, articles and conference proceedings in conceptualising and contextualising praxis and praxis) and analysis and interpretation of existing research data as advised by Verschuren and Doorewaard (1999), especially those that lens occurrence of practice and praxis in the Eastern coast of Tanzania (Fig. 1).

Analysis of primary data involved three sorts of coding in qualitative research, namely, "descriptive, topic, and analytical" as advised by Richards (2005). Descriptive coding focused on describing emerging themes to the level that would allow them to be further analysed. Topic coding, in this case referred to assigning emerging themes under specific topics or sub-topics. And analytical coding focused on recontextualising captured data to examine whether the concepts of practice and praxis were a useful initial stage for sub-subsequent levels or layers of analysis.

Figure 1: Map of the Eastern Coast of Tanzania indicating regions and districts that are involved in coastal-based practice and praxis (Envirocare, Fea and Tacoecont, 2010).

RESULTS AND DISSCUSSION

Summary of secondary data findings

Integrate Coastal Management (ICM) was adopted in the coastal area of Tanzania in the 1990s as a solution to institutional overlaps, coastal resource use conflicts, and mismanagement of resources such as mangroves, fisheries, seagrass, coral reefs, and coastal land (TCMP, 1999a). It leads to praxis-based initiatives that involved various local actors in needs assessment, collective planning, and laying down implementation strategies to achieve agreed initiatives. It prioritized knowledge creation, sharing, and capacity building through processes of training, experiential learning, and engaging in participatory monitoring of coastal resources. It therefore facilitated participatory or collective action by encouraging knowledge sharing towards sustainable use of coastal and marine resources such as mangroves, fisheries, coastal land, seaweed/grass and Cora reefs (TCMP, 1999b).

ICM actions in the 1990s include: Tanga Coastal Zone Conservation and Development Programme (TCZCDP); Rural Integrated Project Support (RIPS); Mafia Island Marine Park (the first Marine Park in Tanzania) established under the Marine Parks; and Reserve ACT.29 of 1994; Rufiji Environment Management Project (REMP); National Mangrove Management Project (NMMP); Saadani Mkwaja Game Reserve; and Kinondoni Integrated Coastal Area Management Programme (KICAMP). All of these initiatives were guided by the principles of ICM (TCMP, 1999a, b); and we can therefore assume that they all employed praxis.

However, while these coastal projects embodied the characteristics of praxis, such as community participation; there was simultaneously a second pattern of activities present that was practice-based. These practice-based activities did not take into consideration the future of the coastal and marine resources. They allowed actors – in processes reminiscent of the tragedy of the commons (Hardin, 1968) – to achieve quick gains guided by experience and routine. They included: the use of coastal mangrove trees to make charcoal; the use of coral reefs to make lime; and the clearing of mangroves to establish salt-pans, make boats or build residential housing (NICEMS, 2003; KICAMP, 2001; KICAMP, 2004). There was therefore a significant distinction between praxis and practice in the natural resource management context (Kemmis and Smith, 2008; NICEMS, 2003; KICAMP, 2001; KICAMP, 2004).

Summary of primary data findings

The collection of primary data revealed few praxis-orientated activities embarked upon by the locals and facilitated by institutions involved in Integrated Coastal Management. These included: seed harvesting and nursery preparation; seedling transplanting; seed germination; mangrove forests as useful sites for beekeeping; seaweed farming; crab fattening; mariculture.

Seed harvesting and nursery preparation

Mangrove restorers know the flowering seasons for different mangrove species. When mangrove seeds mature, special nurseries are prepared followed by seed harvesting, selection and transplanting. The number and type of nursery grounds are thus dependent on the need on the ground. Caring for the nursery requires knowledge as it involves the need to understand different needs or requirements for particular mangrove species. Seeds from *Avicennia marina* (locally called mchu) grow faster and adapt more easily to the nursery environment than other mangrove species such as *Bruguiera gymnorrhiza* (msinzi or muia), *Ceriops tagal* (mkandaa), *Rhizophora mucronata* (mkoko), *Sonneratia alba* (mpia) and *Xylocarpus granatum* (mkomafi). Each nursery plot serves a purpose for specific mangrove species depending on identified needs. In other words, a nursery that is aimed for raising Ceriops tagal (mkandaa) is restricted for this particular seedling production and “labelled” to simplify identification.

Seedling transplanting

Mangrove seedlings transplanting as a form of *praxis* is done where were affected by mangrove clearance *practices* which in most cases appear as bare sites. The demand for seedlings that are required for transplanting in a particular time of the year depends on the size of bare sites observed in the mangrove forest and the type of species that are affected.

Seed germination

Members of the coastal community, who have never been inducted to the practice before, learn from others as they observe how seeds are picked from mature plants, sorted, soaked for at least 24 hours to quicken germination, and later planted in rows in the nurseries. When the new members are familiar with the practice, they also pass the knowledge they have acquired to others up to a level that attracts more active participation and learning. *Avicennia marina* (mchu) and *Xylocarpus granatum* (mkomafi) produce round fruits. The former produces small to medium round fruits which can be collected for nursery purposes while the latter tend to bear much bigger fruits which contain several seeds (Berjack et al., 2011).

Seeds are released when the outer skin of mature fruit tears due to falling or decaying. Mangrove species like *Ceriops tagal* (mkandaa), *Rhizophora mucronata* (mkoko), and *Sonneratia alba* (mpia) tend to produce seeds which germinate while still on the parent plant which enables them to rapidly establish in soft sediments “without being washed away by tide” (Scheltinga et al., 2004). These hang downward, facing the ground, and have sharp endings which stick and germinate in the mudd after falling. These seeds can also be harvested and planted in nursery grounds or directly pinned to the ground by mangrove restorers.

Mangrove forests as useful sites for beekeeping

In the coastal area, beekeeping is carried out as practice and praxis at the same time. Some members of the coastal community started engaging in beekeeping after attending organized training sessions under the support of ICM programmes in their areas. These later pursued specified logical plans to implement beekeeping in the mangroves. On the contrary, some individuals practice beekeeping in the absence of logical plans or without carrying on board community aspirations and expectations. The latter as alluded earlier in the introductory part is a form of practice rather than praxis (Kemmis and Smith, 2008).

Be keeping as an emerging viable economic praxis has many benefits, not only to coastal communities as an income generating activity, but also to the mangrove ecosystem. Mangrove restorers select certain mature mangrove plants which can support the installation of modern beehives. Areas that are covered by beehives remain undisturbed throughout the year in fear of the *African honey bees* which are aggressive by nature (Hodgson et al., 2010) and can attack people who disturb the surrounding environment or who cut trees near the beehives. Honey and bee products from the mangrove area are considered to have medicinal benefits, and are thus widely preferred by coastal dwellers to honey from terrestrial forests.

Seaweed farming

Seaweed farming is a common practice in the study area. There are two species that are farmed in the Eastern Coast of Tanzania. These are *Eucheuma spinosum* and *Eucheuma cotonii*. Seaweed farming is practiced at a medium scale where selected species are tied in specified strings and placed in deep or shallow water to grow. Harvesting time range from few weeks to three months, depending on location of the farm and absence of predators such as rabbit fish (*Siganus* spp.) and other fish (Talbot and Wilkinson, 2001). Rafts such as plastic bottles or other light materials are also tied to the string (s) to help seaweed farmers identify farm demarcations, as these float and may easily be seen or detected from a distance.

Several studies have associated seaweed farming with increased catches of particular fish species. These studies reveal that fishing traps (gear) set near seaweed farms caught three times more fish than those placed elsewhere (Eklöf et al., 2006).

Crab fattening

Crab fattening is simply an act of catching or fishing mud crabs (*Scylla serrata*) and keeping them in locally made cages in the mangrove areas and feeding them until their weight increases relatively. Mud crabs are caught at juvenile stage and are fed with fish off al organs of animals such as livers, hearts, intestines, etc., internal, oyster meat, and gastropods (Melita et al., 2008) to encourage quick growth to market size. This process seems to be viable economically since crab weight determines the price. The more the weight the higher the income. Locally made cages require traditional skills and knowledge, and this can be carried out by people who understand the biological and natural behaviour of the crabs. In spite of the fact that crab fattening is a morally accepted action, it is still narrowly practiced in the coastal area and may hardly qualify to be regarded as a form of praxis as there are very few individuals who are engaged in it and they do it through locally acquired experiences.

Mariculture

The Tanzanian Coast also has the potential for oyster farming as a type of mariculture but this does not involve local creativity as it is the case in other parts of the coastal area. Unlike crabs, oysters are directly harvested from their natural environment and consumed. Mangrove oysters (*Saccostrea cucullat*) are common and abundant on the eastern coast of Tanzania as a potential *culture* species (Rice et al., 2006). Oyster farming allows involved actors to raise oysters either for commercial purposes or home consumption (Rice et al., 2006). It is believed that this form of practice is not widely carried out, due to a limited market and the abundance of wild oysters (TCZCDP-2008).

Discussion of praxis-oriented activities

The described activities exhibit the characteristics of praxis because they induce benefits to the environment and the local human communities. Preparation of nursery grounds and transplanting seedling contribute to the maintenance of the mangroves and therefore protect the socioeconomic environment. They encourage not only learning by doing among mangrove restorers, but also knowledge transfer from individual levels to a wider level of the social unit (i.e. social learning). Some of the activities allow individuals to use resources, or add value to them, in non-exploitative ways. For instance, seaweed-farming, crab-fattening and mariculture, carried out appropriately, need not be harmful to the environment but significantly increase resource yields. Such activities may have also have beneficial effects on the local ecology, for instance, bees contribute to species pollination and seaweed creates habitats for fish species. Praxis, according to this definition, requires that actors do not take advice on the basis of external authority alone; rather actors are guided by the logic of the context, and decisions are made collectively. This makes praxis profoundly democratic.

Prior to the introduction of beekeeping and other economic practices like crab fattening in the mangroves, the secondary data revealed that there were debates over whether it was justified to include poor communities in projects such as mangrove restoration, since it was believed that these had no direct and tangible benefits to the people (KICAMP, 2003). Such debates no longer exist – as the benefits are now clear – and more people, especially women, are attracted to such projects in the mangrove sites. Additionally, it was arguably paternalistic of the people who engaged in such debates, in that they assumed that local people would not value the long-term advantages of protecting the mangroves.

An explanation for how the poor communities came to engage in praxis is specifically provided by the idea of Community of Practice (CP) developed by Etienne Wenger (1998) to serve as a lens for indicating a process pursued by people with a shared concern or passion – in a defined domain – as they learn how to do better through regular interactions. As these people work together, they develop a form of specific common identity, leading to shared commitment and also competencies. Similarly, the events and praxis described in this particular article can be understood in terms of the theoretical concept known as “experiential learning” which draws heavily on Kolb’s theory of Experiential Learning (Kolb, 1984). It explains how people learn as they engage in practice, the role of experience in the learning process, and the learning styles that emerge as actors immerse in the learning practice or praxis.

How to achieve praxis rather than practice

Praxis is a particular kind of “action” (Kemmis and Smith, 2008). In order to understand it fully, there is a need to abstract it further by isolating out some of its key component parts, particularly those that differentiate it from a mere action or social practice. As alluded in the preamble, it is a kind of action that takes into account not only individual interests but also long term interests of the society or a particular community (ibid.), and a *morally*-committed and oriented action that is informed by traditions in the field and expectations of bringing about some kind of transformation in the social world. Praxis tends to accommodate reflections and reflexivity of involved communities. It avails a space for target communities to pursue logically planned actions and improve, correct, or replace them as they engage in continued the implementation process. Any actions that encourage reflexivity are capable of providing a space for involved communities to critique their own work and generate a higher degree of freedom to for them to point out constraints and needs that are necessary for achieving the intended results (Bourdieu, 2004). Through such a process, there is always some kind of learning which is being attained (Wals, 2007). This kind of learning, that allows people to learn as they engage in practice, is also known as Experiential Learning (Kolb, 1984; NEECS, 2004).

Developing *praxis* requires opportunities for experiential learning and an environment that favours field work and traditions of practice (Kemmis and Smith, 2008). It requires that learners identify themselves as people who try to develop their knowledge and practices within their social context through action, experience, and reflection (ibid.).

Knowledge was gained through both personal and environmental experiences (Kolb, 1984). Kolb argues further that for knowledge to be gained, four conditions must be fulfilled; firstly, the learner must be willing to be actively involved in an experience; secondly, he or she must be able to reflect on the experience; thirdly, she or he must be able to conceptualize that particular experience; and finally, he or she should possess decision making and problem solving skills in order to apply ideas gained from experience (ibid.). The second and third conditions that Kolb brings into consideration can hardly be reached without the process of *abstraction* and careful conceptualisation. The last condition in the process of “experiential learning” which requires the learner’s ability and skills to internalize gained knowledge or experience can be referred as “Praxis”. It is at this point that *praxis* potentially affects *experiential learning.*

Monitoring as a form of praxis which attracts learning

Monitoring is defined as a process that involves repeated surveys in which “qualitative or quantitative” observations are made (Hill et al., 2005). It involves detecting of changes, trends, threats, and the condition of specified parameters of the environment (KIMP, 2005), and is carried out for different purposes depending on what it is aimed at (Hill et al., 2005). Monitoring is a good ground for experiential learning, and as discussed earlier in this article, it potentially allows actors (local communities) to learn from each other to the level that may enhance their praxis and attract a wider participation of learners.

Hill et al. (2005) insist that a monitoring programme needs to have a defined or formulated standard; which should specify the kinds of *features* that will be monitored, for example mangroves, and fisheries; it should also specify *attributes* for selected features’ (e.g. soil, vegetation cover, etc.) target state, and the methods that will be employed in the process of monitoring. Monitoring, according to Hill et al. (2005), should therefore: establish whether standards are being met; detect change and trigger responses if any of the changes are undesirable; contribute to the diagnosis of the causes of change; and assess the success of actions taken to maintain standards or to reverse undesirable changes, and where necessary, contribute to their improvement.

Formulating “standards” implies choosing a preferred monitoring-route that is based on actors’ priorities or preferences. The “standard” therefore, serves as a guideline of inclusion and exclusion of monitoring parameters all of which depict a praxis path.

Monitoring as a form of praxis in the coastal area requires an agreed set of parameters, attributes, and methods or techniques (KIMP, 2005). General monitored parameters include trends, condition, threats and changes (ibid.). Monitored attributes vary across prioritized natural resources; and their selection will normally depend on the purpose of monitoring and the resource condition (Hill et al., 2005).

CONCLUSIONS

Praxis has a positive connotation. Its epistemology facilitates the adoption of moral actions based on the logical nature of an intervention and protects or benefits the wider community. Praxis is associated with reflexivity, in that, it allows involved actors to reflexively consider their actions and improve or discard unwanted ones. It results in creative approaches to novel situations and its base in democratic, collective decision making makes it ethically sound, since it avoids top-down management. There are cases where adopted logical plans fail to capture local needs and concerns; but these are always potentially resolvable since praxis-oriented initiatives encourage learning from mistakes. There are many well-established approaches and tools that can assist in the achievement of praxis, such as: Wenger’s (1998) theory of Communities of Practice; Kolb’s (1984) theory of Experiential Learning; and general features of monitoring and evaluation, see for example Hill et al. (2005).

Practice, as defined in this article, is usually problematic. Even if its immediate form is harmless or beneficial, there is always the potential for practice to result in disadvantageous actions, especially over-time. This is because it cannot account for changes in circumstances and its lack of reflexivity denies the possibility of monitoring and behaviour adjustments. Because it does not necessarily consider the wider community or long term consequences, it is susceptible to the problem of the tragedy of the commons. Not only does practice encourage detrimental activities; it can also inhibit the expansion of activities that are beneficial, as is the case with crab-fattening. By differentiating between practice and praxis, is hoped that resource managers will be better equipped to develop greater praxis in resource management contexts.

ACKNOWLEDGEMENT

Acknowledgement goes to coastal communities who took part in this research and Mrs. Lotz-Sisitka H., and Mr. O'Donoghue R. for advising me on various issues that relate to learning in the coastal context. I would also like to thank Mrs. Leigh Price for useful comments on an early draft.

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