Project title: Constructed Wetland for Nutrient Reductions in the Waters of Tirana River (1 November 2009 - 31 August 2010)

SECOND ENVIRONMENTAL PROGRESS REPORT RELATED WITH THE NEW CONSTRUCTED WETLAND IN THE PLACE BREGU LUMIT (TIRANA RIVER)

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About the project

Institute for Environmental Policy (IEP; http://www.iep-al.org/), in partnership with Ekolëvizja and Tirana Municipality, was involved in the project "Constructed Wetland for Nutrient Reductions in the Waters of Tirana River in Albania", supported by the Living Water Exchange Program, GETF on behalf of GEF/UNDP (http://iep-al.org/index.php?option=com_content&view=article&id=84:constructed-wetland-for-nutrient-reductions-in-the-waters-of-tirana-river&catid=40:water-management&Itemid=88). The principal aim of the project was to bulid up a wetland for one or two discharge channels, in the place known as Bregu Lumit (Fig. 1), in order to reduce the nutrients input in Tirana River. The place is found ca. 2 km far from the main road Ferid Xhajku (known as Unaza) at the north-eastern part of Tirana; it can be reached through the road 5 Maj (Fig. 1); at the end of the road, there are some abandoned rests of the former industrial place (former Chemical Enterprise); the place now is almost urbanized by small houses; some of them in the way of building even in the present day, even less than 30 m far from the river bank.

In this place, two small wastewater channels were under the focus of the wetland treatment process (Fig. 2, 3A&B); the channels were close to each other (ca. 20 m); their water course was low, running in open part only ca. 20 m far form the lakeshore; their upstream part goes under ground in a collecting pipeline. Probably, these two channels were formerly small torrents, transformed in collectors of the wastewater from the urbanized and the former industrial area. Their open part was mostly naturalized, covered scarcely by the vegetation, like shrubs of *Salix* sp., *Rubus* sp. and *Typha* sp., and heavy bacterial patches. The riverbanks were almost transformed from its natural state, due to the rests of the building materials deposited along. The riverbed is build up of gravel and stones; the water course was higher than normal in February 2010, due to the heavy rainfall during previous period; the color of the water was green milky, highly turbid, due to the high amount of suspended solids; the river course was at its rather normal flow in July 2010, and not so turbud as it February. Riverbed as the riverbanks were heavily spoiled with plastic garbage and other solid waste. The photos in the figure 3 show different views from the discharge channel (A and B), where the wetland is build up, and from the river place Bregu Lumit (C and D).

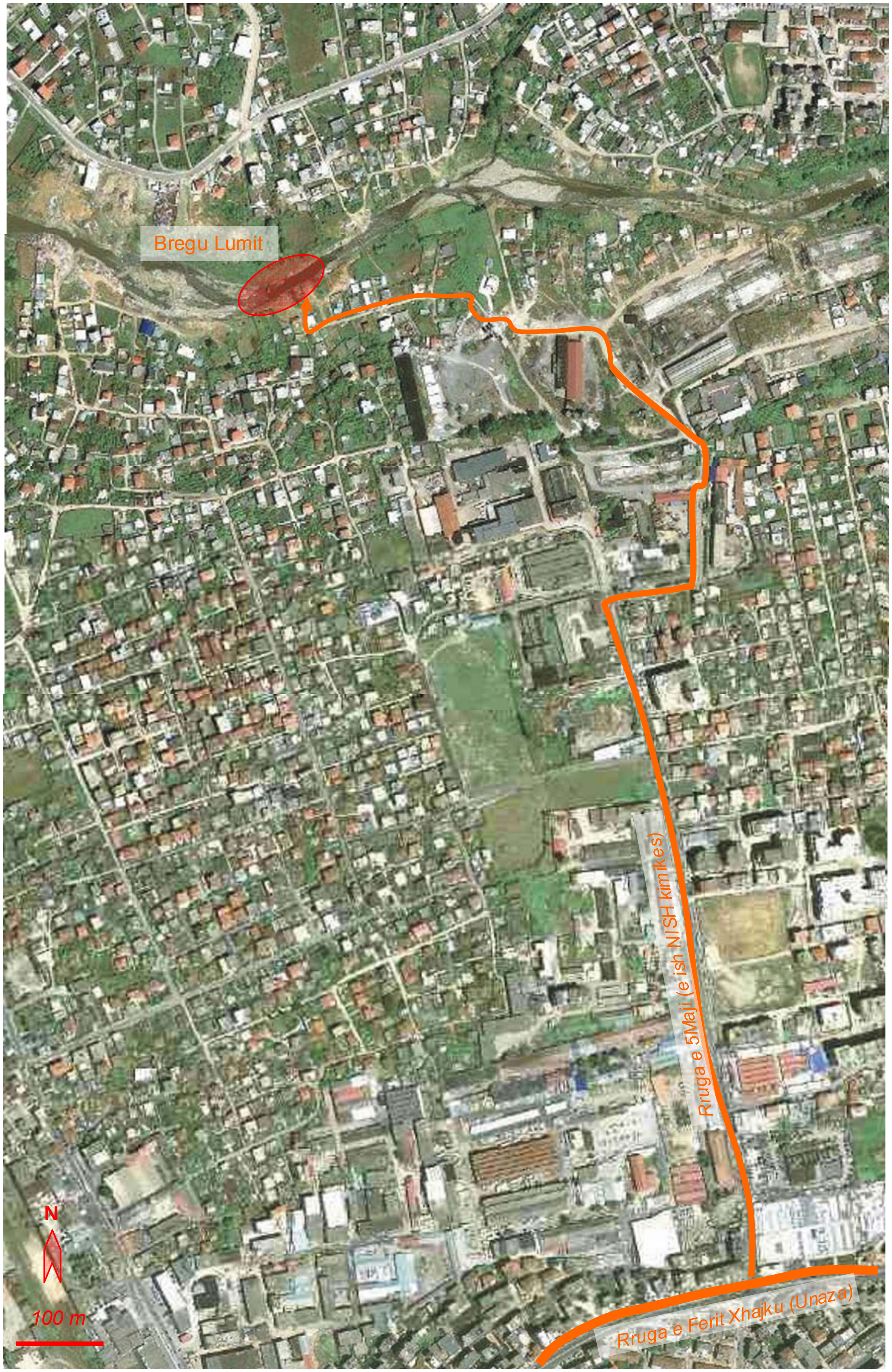

Figure 1. Satellite view where the river place Bregu Lumit, River Tirana, is shown (elaborated after Image © Terremetrics, Europe Technologies and Digital Globe, Google Earth 2008).

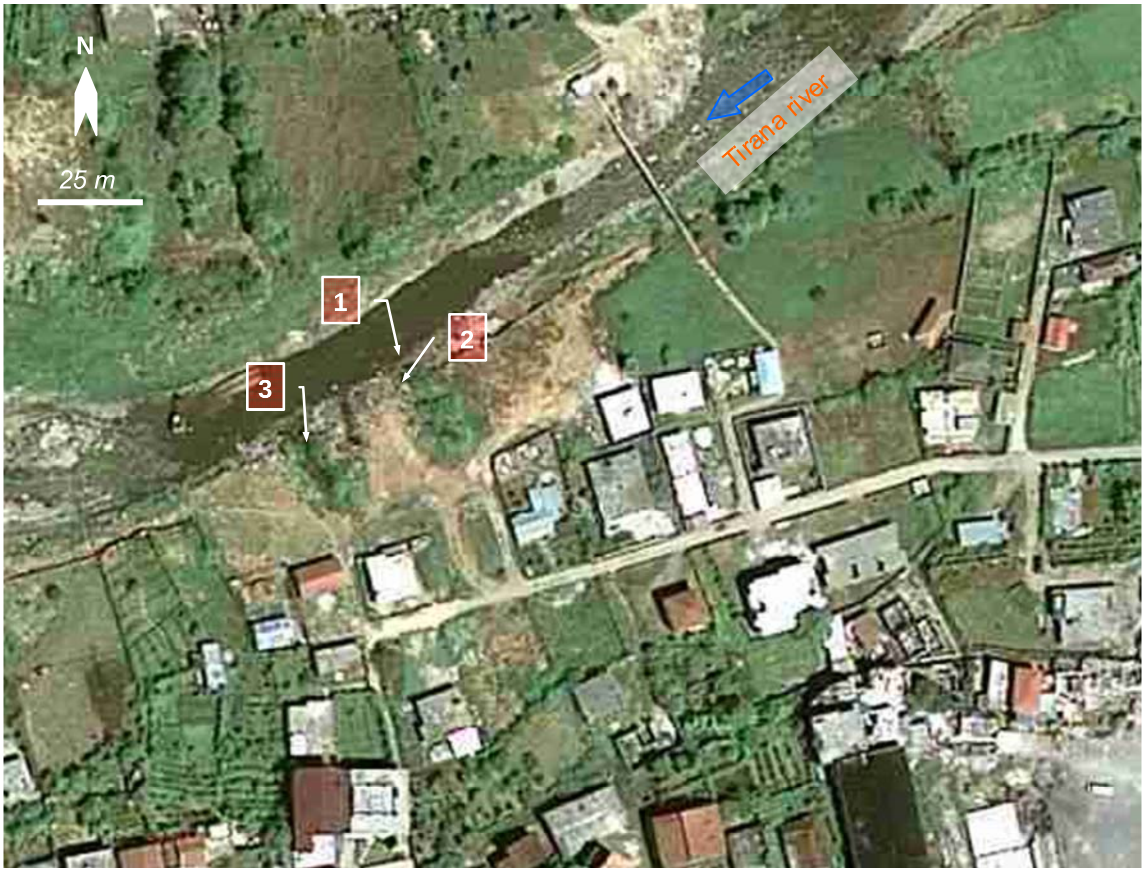

Figure 2. Satellite view of the place in the river plac in Bregu Lumit, River Tirana, with thr first the three sampling stations (09.02.2010) (elaborated after Image © Terremetrics, Europe Technologies and Digital Globe, Google Earth 2008).

During March-May 2010 the wetland was build up, in the mentioned place (Fig. 2) (IPM & Ekolevizja, 2010a; http://iep-al.org/docs/wetland_leaflet_web.pdf). It is composed of three shallow ponds, with total dimensions of 5 m wide x 25 m long (Fig. 4), separated with concrete walls; therefore the total surface is 375 m^2. The wetland system consists in **surface flow** (Fig. 5), where reedbed of *Typha* was cultivated (Fig. 4). The plants were just started to grow up mixed with other aquatic grasses. A lot of algal patches were evidently floating in the water together with macro-invertebrates. Nevertheless, the wetland was far to be in natural shape; its functioning related with water purification was relatively scarce. It will take probably some time, probably few years, until it will get its natural aspect. Moreover, the habitat was stinking, due to the heavy phenols from waste water discharge.

It is worth to mention that a constructed wetland or wetpark is an artificial marsh or swamp, created for anthropogenic discharge such as wastewater, stormwater runoff or sewage treatment, and as habitat for wildlife, or for land reclamation after mining or other disturbance. Natural wetlands act as biofilter, removing sediments and pollutants such as heavy metals from the water. Vegetation in a wetland provides a substrate (roots, stems, and leaves) upon which microorganisms can grow as they break down organic materials. This community of microorganisms is known as the periphyton. The periphyton and natural chemical processes are responsible for approximately 90 percent of pollutant removal and waste breakdown.

Figure 3. Photos from the river place Bregu Lumit: A-B) view of the discharge channel (sampling station 2); C-D) views from the down and upstream parts of the river (sampling station 1) (from A. Miho).

Figure 4. View of the constructed wetland in the Bregu Lumit, River Tirana (from http://iep-al.org/index.php?option=com_joomgallery&func=viewcategory&catid=5&Itemid=74)

The plants remove about seven to ten percent of pollutants, and act as a carbon source for the microbes when they decay. Different species of aquatic plants have different rates of heavy metal uptake, a consideration for plant selection in a constructed wetland used for water treatment (http://en.wikipedia.org/wiki/Constructed_wetland). Cattails (*Typha latifolia*) are commonly used in constructed wetlands because of their widespread abundance and general availability, ability to grow at different water depths, ease of transport and transplantation, and broad tolerance of water composition (including pH, salinity, dissolved oxygen and contaminant concentrations).

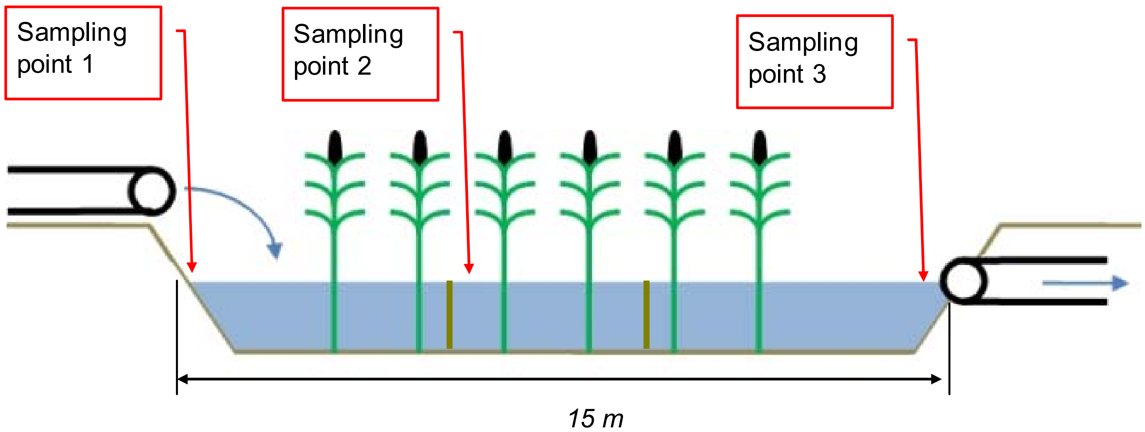

Figure 5. Scheme of the cross section of the constructed wetland in the Bregu Lumit, River Tirana, with the three sampled stations in the second assessement (05.07.2010) (elaborated from http://en.wikipedia.org/wiki/Constructed_wetland)

The **first report** on the environmental assessment was prepared in February 2010, already available on the website (http://iep-al.org/docs/TIRANA%20RIVER-%20Environmental%20Report.pdf). The **second report** is presented here, aiming on the progress shown after the build up of the wetland in May 2010 in the mentioned place, compared also with the data obtained during the first assessment (February 2010).

The group of experts and the visits

Both environmental assessments were carried on by the group of **chemists** and **biologists** from the Faculty of Natural Sciences, Tirana University:

- Dr. S. Duka, chemist, working group of Analytical Chemistry, Department of Chemistry;
- Prof. M. Hysko, microbiologist, working group of Molecular Biology-Microbiology, Department of Biology;
- Prof. A. Miho, botanist (microscopic algae - diatoms), working group of Botany, Department of Biology; T. Besatari, a student of the first year of the course of Environmental Biology (Second Level; DND), is joined with the group working with diatoms and related ecological indexes as a part of her diploma theses, intended to be sustained in July 2011.

Three visits were carried on in the zone:

- The **first visit** was in 19 January 2010, aiming to know with the place and select the most proper stations for monitoring.

- The **second visit** was in 09 February 2010, ore 13.00 (Fig. 6), where the samples were collected, and other measurements in situ were carried on. The details about the sampling stations, and types of the samples collected were given in the table 1, and shown in the satellite map of figure 2. Four set of samples were collected (Tab. 1): a) for physical-chemical analysis; b) nutrients (nitrogen and phosphorous; c) for microbiological state; and d) for periphyton (microscopic algae – siliceous algae or diatoms - *Bacillariophyta*).
- The **third visit** was in 05 July 20010, after the wetland was build up. The details about the sampling stations, and types of the samples collected were given in the table 1, and shown in the figure 2. Four set of samples were collected (Tab. 1): a) for physical-chemical analysis; b) nutrients (nitrogen and phosphorous; c) for microbiological state; and d) for periphyton (microscopic algae – siliceous algae or diatoms - *Bacillariophyta*).

Table 1. Sampling codes, stations and other details about the analyses carried on in Bregu Lumit, River Tirana, during two sampling visits (February and July, 2010).

Kode	Station	River	Date	Analyses
1	River	Tirana	09.02.2010	a) Physico-chemical measurements *in situ*; b) Nutrient water samples; c) Microbiological water samples; e) Periphyton samples over plastic garbage submersed on the water
2	Discharge 1 (upstream)			
3	Discharge 2 (downstream)			
1	Pond 1 (water input)	Tirana	05.07.2010	a) Physico-chemical measurements *in situ*; b) Nutrient water samples; c) Microbiological water samples; e) Periphyton samples (diatoms) over floating macrophyte algae on in the first two ponds, and in submersed stones in the water discharge output (Pond 3) and in the river
2	Pond 2			
3	Pond 3 (water output)			
4	River			

Figure 6. Sampling during the second visit in the zone, February 2010 (from http://iep-al.org/index.php?option=com_joomgallery&func=viewcategory&catid=5&Itemid=74)

Methods of the analyses

Physical-chemical analyses ad nutrients: Conductivity, pH, temperature, suspended matter, nitrites, nitrates, ammonium and phosphates were analyzed after Hach (2001) and APHA/AWWA/WPCF (1995). Nutrients: Nitrogen (NO_2-N, NO_3-N, NH_4-N) and phosphorus (PO_4-P) in water were measured using UV-VIS spectro-photometry, following the standard methods recommended by APHA/AWWA/WPCF (1995). In the table 2, there are reported the guide and the imperative values for the most principal parameters measured, considering the EC Fish Directive 44 (2006) '*Quality of fresh waters supporting fish life*'.

Table 2: *Quality of fresh waters supporting fish life (*EC Fish Directive 44, 2006)*)*

Parameters	***Salmonid waters***		***Ciprinid waters***	
	Imperative	*Guide*	*Imperative*	*Guide*
Total Suspended Solid (TSS, mg/L)		*≤ 25*		*≤ 25*
Phosphates (PO_4, mg/L)		≤ 0.2		≤ 0.4
Nitrites (NO_2, mg/L)		≤ 0.01		≤ 0.03
Ammonium total (NH_4, mg/L)	*≤ 1*	*≤ 0.04*	*≤ 1*	*≤ 0.2*

Tabela 3. Microbiological methods and nutrient media used in each testing type

Test types	**Method**	**Incubation temperature**	**Nutrient media**
Fecal coliforms	MPN	44.5ºC for 24 hours	EC Mc Konkey agar Indol test
Total coliforms	MPN	37ºC For 24 hours	Lactose Broth (LB) Mc Konkey agar
Heterotrophic bacteria	Plating	28ºC and 37ºC for 48 hours	YEA

Microbiologic investigation: The microbiologic investigation was carried on following the relevant ISO standards for microbiological water analyses. About 200-250 mL of water was taken in each station using sterile glass bottles (at 180°C for 90 minutes); the samples were transported in a chilly bin to the laboratory within the sampling day, and tested within 30 hours (ISO 5667-6:1990). The MPN (Most Probable Number) test and the nutrient Media EC were used for the **fecal coliform** testing (Tab. 3); the incubation was done at 44.5ºC. Looking for gas production tubes, the confirmation test in Mc konkey media plating was used and the indol test, as well. The measurement was done by using the MPN statistical tables for river waters and is expressed as the number of organisms per 100 mL (CFU/100ml). The MPN (Most Probable Number) test and the Nutrient Media Lactose Broth (LB) are used for the **total coliform** testing; the incubation was at 37ºC, looking for gas production tubes, and the confirmation test in Mc konkey media plating. The measurements were done by using the MPN statistical tables for river waters. The **heterotrophic bacteria** testing were made by using the YEA Nutrient Media, using the Petri dishes plating; the incubation was in 28º and 37ºC. The measurement is expressed as the number of organisms per 100 mL (CFU/100mL) (Hysko, 2007). EU standards after ISO 7899-1 for fecal and total coliforms of water quality in rivers and streams are given in table 4.

Table 4. Microbiological standards (ISO 7899-1) for fecal and total coliforms of water quality in rivers and streams

Microbiology	EU Standard ISO 7899-1			
	Very good	*Good*	*Bad*	*Very bad*
Fecal coliforms, CFU/100 ml	250-500	500-1,000	1,000-2,000	over 2,000
Total coliforms, CFU/100 ml	1,250	2,500	5,000	10,000

Biological investigation: Communities of microscopic siliceous algae (diatoms–*Bacillariophyta*), growing on garbage substrates and even in clay, or floating in the constructed ponds, were studied by light microscopy, following the EU Guidance standard for the routine sampling and pretreatment of benthic diatoms from rivers (EN13946:2003) and the other EU Guidance standard for the identification, enumeration and interpretation of benthic diatom samples from running waters (EN14407:2001). Cleaning of diatom frustules was done boiling the material with hydrogen peroxide H_2O_2cc. Microscopic slides were prepared using Naphrax (index 1.69) and examined using a LEICA DML microscope (objective 100x). Determination of the species was based on Krammer & Lange-Bertalot (1986-2005) keys. To get reliable data (confidence 95%; with an error ±10) more than 400 valves were counted in the microscope. Permanent slides are deposited in the Lab of Botany, Tirana University.

The Trophic Index of Diatoms (TI_{DIA}; ROTT *et al*., 1999; 2003), Saprobic Index (SI; ROTT *et al.,* 1997) and the Index of Pollution Sensitivity (IPS, originally developed by Coste in Cemagref, 1982) were calculated using the formula of Zelinka & Marvan (1961). Of the above indices, only the IPS (Index of Pollution Sensitivity), show strong correlations to organic pollution (BOD, COD, total N and particularly P), ionic strength (chloride, sulphate, conductivity) and eutrophication (chlorophyll and nitrate) (Prygiel & Coste, 1993). In addition, the Diversity Index (H'; Shannon & Weaver, 1949) was calculated, too. In table 5 there are reported the class boundary limits for IPS.

Table 5: Class boundary limits for IPS (Indice de Polluosensibilité Spécifique or Index of Pollution Sensitivity) in different European countries (after Coste in Cemagref, 1982)

Cilësia / Quality	Francë, Belgjikë	Suedi
Lartë/High	17 ≤ IPS ≤ 20	17.5 ≤ IPS ≤ 20
Mirë / Good	13 ≤ IPS ≤ 17	14 ≤ IPS ≤ 17.5
Mesatare / Moderate	9 ≤ IPS ≤ 13	10.5 ≤ IPS ≤ 14
Varfër / Poor	5 ≤ IPS ≤ 9	7 ≤ IPS ≤ 10.5
Keqe / Bad	IPS < 5	IPS < 7

General consideration about the environmental sate of the mew constructed wetland in comparison with the former place

In July 2010 the river flow was relatively low, if compared with that in February, and the turbidity was not evident as it was in February 2010. Nevertheless, the place, riverbanks continue to be always dirty and even the bed smell continues to be quite strong all a round the place of the riverbanks (Figs. 3, 4 & 6) and constructed wetland. Moreover, new buildings grew up quickly, one of them close to the constructed wetland and the riverbank.

From the principal parameters, we can point out that nutrients, **nitrogen and phosphorous were relatively higher** than in February 2010 (Tab. 7); hence, the phosphates (PO_4^{3-}), in the river raised up from ca. 0.8 mg/L in February to ca. 1.3 mg/L in July; phosphorous was always higher in the three constructed ponds than in original channels in February 2010, with a slight increasing trend from the pond 1 to the pond 3 (Fig. 7); the phosphates were all higher than 0.4 mg/L, the EC Fish Directive guide value for *Cyprinid* waters (Tab. 2). It is worth to mention that the high content of phosphorous in waters enhances the growth of algae, some of them can be also toxic, or often with anesthetically values.

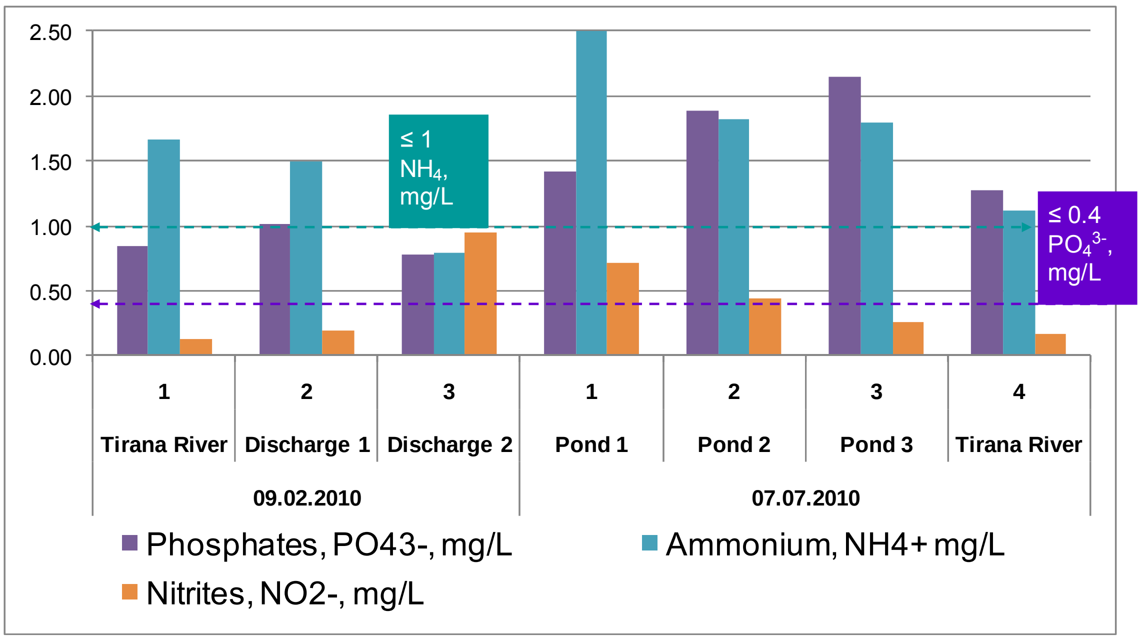

Figura 7. Phosphates (PO_4^{3-}, mg/L), nitrites (NO_2^-, mg/L) and ammonium (NH_4^+, mg/L) in two stations (discharges 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the same data measured in three ponds (ponds 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010.

Ammonium content (NH_4^+, mg/L) in the three constructed ponds was higher, than the related values of the discharging channels in February 2010, with a slight decrease from the pond 1 (input) to the pond 3 (output); nevertheless, even ammonium continues to be always higher than 1 mg/L (Fig. 7), the EC Fish Directive **imperative** value for *Cyprinid* waters (Tab. 2). The same comments can be given also for the nitrites; but for them a certain decrease is observed from the pond 1 (0.72 mg/L NO_2^-), to 0.42 mg/L (pond 2) and 0.27 mg/L (pond 3) (Tab. 7; Fig. 7); but all these values are much higher than 0.03 mg/L NO_2^-, the EC Fish Directive guide value for *Cyprinid* waters (Tab. 2). Many effluents, including sewage, are rich in ammonia; nitrites are intermediates in the oxidation of ammonia to nitrate; therefore, the high levels of nitrate in river waters indicate directly the high pollution (http://www.mtstmichael.ie/MSM-Water2000/MSM-Riverwaterquality.html). The high level of ammonium and nitrites indicates reducing conditions in the river and in the constructed ponds due to the high organic load, as a direct consequence of untreated liquid wastes from the two channels. The situation was also shown in other stations of Tirana River, as well as other tributaries of Ishmi river, Lana and Gjola (Çullaj *et al.,* 2005; Miho *et al.,* 2005). Form this data, and form the other microbiological and biological data shown below we can conclude that the **efficiency of the water treatment in the constructed pond is low**, far from its natural state; we can say that in this period, it seems even lower than the self treatment made from the natural channels, their natural vegetation, in the former state.

Suspended solids (TSS) in the river were relatively low, either in the former channels and in constructed ponds; in the River TSS was 29 mg/L (Tab. 7), exceeding slightly the value of 25 mg/L, the EC Fish Directive 44 (2006), but it was much lower as it was in February 2010 (117.14 mg/L). It is worth to mention that the high content of suspended solids (TSS) is quite common in river courses of Western Adriatic Lowland, as evidenced in other monitoring activities (Çullaj *et al.,* 2005; Miho *et al.*, 2005); it show the high rates of soil erosion upstream, as a direct evidence of poor land use activities in their respective watershed areas, such as woodcutting, overgrazing, even intense gravel mining in the riverbeds; gravel mining is also evident and continuous present along the riverbed of Tirana, as well.

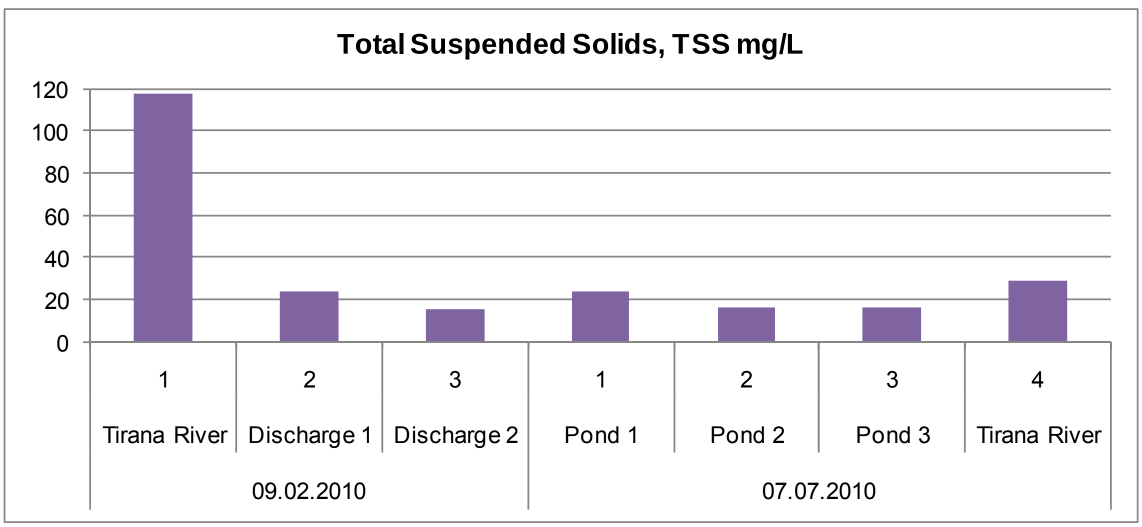

Figura 8. Total Suspended Solid (TSS, mg/L) assessed in two stations (discharges 1 & 2), and in Tirana river in Bregu Lumit, in 09.02.2010, compared with the same data measured in three ponds (ponds 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

Troendle (2002) summarized also in his report about the Albanian Watershed Assessment that the principal factors of land degradation in Albania are erosion and sedimentation caused by poor land use practices, deforestation or gravel mining. Miho *et al. (*2009) discussed also the pour land use, soil erosion and related human activity in Bovilla watershed, the main drinking water source for Tirana town, part of Tërkuza and Ishmi watershed.

The microbiological data are slightly lower than the respective values measure in February (Tab. 7); there is also a slight decrease from the pond 1 (input) to the pond 3 (output) (Fig. 9 & 10) in all the parameters, showing **some positive effect on the water treatment from the new established wetland**. Surprisingly, the related content in the river in July 2010 was also much lower than in February 2010, for all parameters, despite the low water in summer season, and eventual concentration; it shows how the rainfall in winter period helps washing out the urban wastes from the surrounding watershed and increasing the bacterial pollution of surface waters. Nevertheless, **the values of fecal coliforms and total coliforms continue to be several folds higher than 2000 CFU/100 ml and 10'000 CFU/100ml, respective values of the EU Standard ISO 7899-1.** It means that that the water quality continues to be very bad and very dangerous for the local people living in the area, but also for the whole community along Tirana and Ishmi river banks.

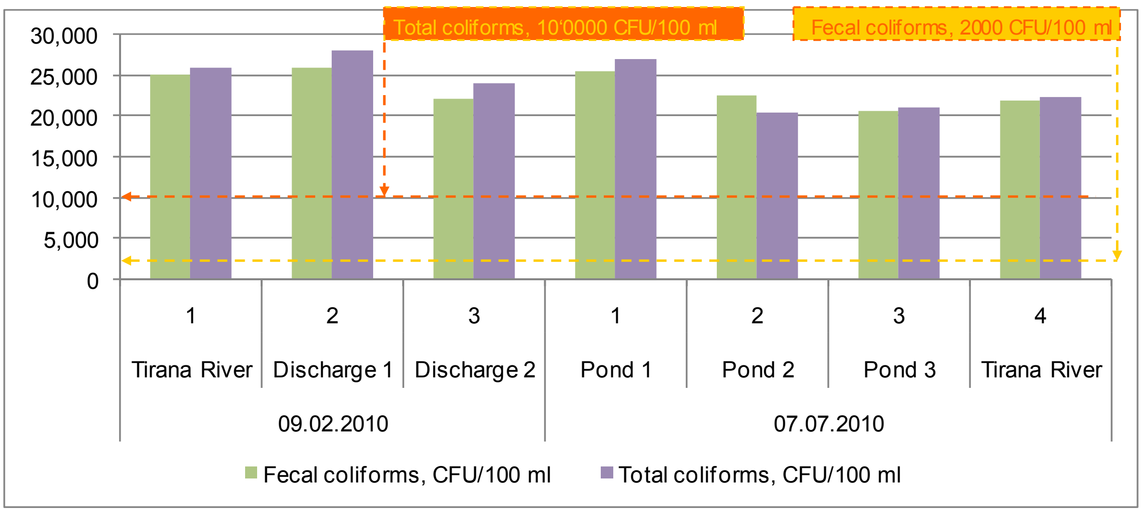

Figura 9. Fecal coliforms and total coliforms (CFU/100 ml) assessed in two stations (discharges 1 & 2), and in Tirana river in Bregu Lumit, in 09.02.2010, compared with the same data measured in three ponds (ponds 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

It is worth to evidence that the presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in surrounding ambient and water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

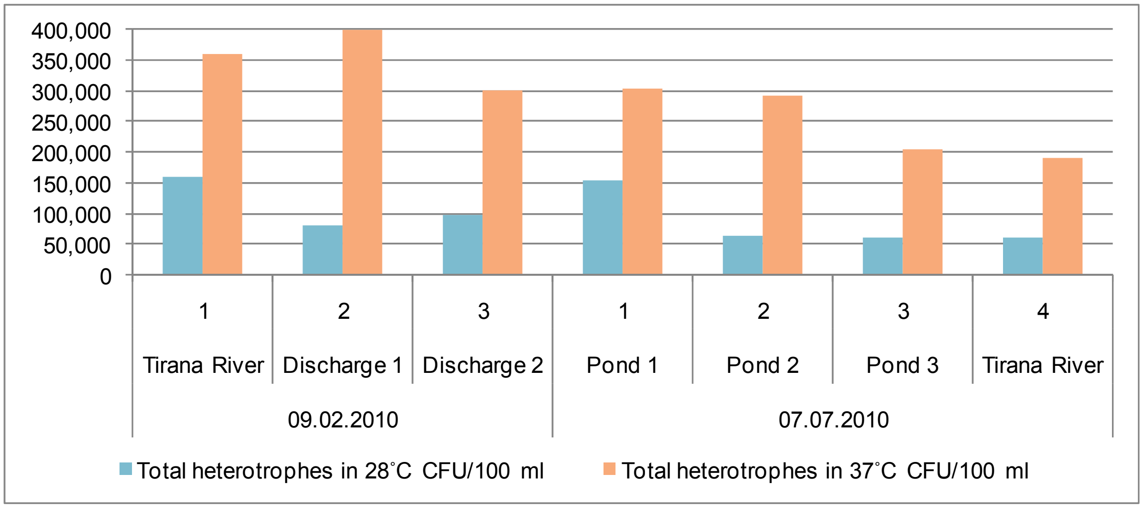

Figure 10. Total heterotrophes (CFU/100 ml) in 28ºC and 37ºC, respectively, in two stations (discharges 1 & 2), and in Tirana river in Bregu Lumit, in 09.02.2010, compared with the same data measured in three ponds (ponds 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

The structure of diatom community (siliceous microscopic algae – group *Bacillariophyceae*) was rather different from the first assessment made in February 2010. The community in July 2010 was strictly dominated by species of genus *Nitszshia,* composed mostly by *eutraphent* or tolerant species, that can grow up easily in polluted waters; in all the ponds *Nitzschia umbonata* dominated (from 41% in pond 3 up to 87% in pond 2); the other eutraphent species, *Nitzscia palea*, grow up there where *N. umbonata* was relatively lower, i.e. up to 50% in pond 3 and 67% in the river. *Nitzschia palea* was often present in Albanian polluted rivers, like Lana and Gjola (Miho *et al*., 2005; 2008). *N. umbonata* was found abundant only during the present state in the three constructed ponds; it is probably linked with the heavier content in the new established habitat of total dissolved solids, nitrates, conductivity and turbidity, as seen elsewhere in other polluted waters. These two species are known to be tolerant to very heavy pollution (i.e. Tockner *et al*., 2009), growing up in very high nutrient and organic concentrations; optimum of growth known for *N. palea* is between 0.35 and 1 mg/L filterable phosphorous (http://craticula.ncl.ac.uk/EADiatomKey/html/taxon13540980.html).

About 90 diatom species were found in two assessed tours (Tab. 9), only 5 species were centrics the dominant part were pennate. From the centrics, only *Stephanodiscus medius* was relatively abundant (about 16% of the diatom community) in Tirana River (February 2010); other abundant species of pinnate diatoms observed during the first tour of sampling were *Amphora montana* (about 10% in the first channel), *Fragilaria ulna* (ca. 10% in the River), *Nitzschia incospicua* (ca. 14% in the first channel), *N. palea* (more than 21% in the first channel), *Nitzschia* cf. *pusilla* (ca. 16% in the second channel). During the second tour (July 2010) the abundant species were more evident, *Nitzscia palea*, with more than 50% in pond 3 and more than 67% in the River; while, *N. umbonata* was ca. 73% in pond 1, ca. 87% in pond 2 and more than 41% in pond 3. As it can be observed from the frequencies in table 9, during the first tour the number of species was higher and more balanced in abundance; while in July 2010 only one or two species were dominant; this unbalanced mode of species distribution, in number and relative abundance, is the cause of low diversity index in July 2010, compared with February 2010.

Total number of species in two channels in February was relatively higher compared with low number of species found in the three ponds (Tab. 8; Fig. 11). It shows **the instability of the ponds, far for their normal natural state**; as stressed above it will need some time until the wetland will gain its normal biodiversity, expressed also with the normal number of diatom species. As it is expected the number of the species in the River was higher than in February, due to the favorable climate conditions. As it was stressed in the first report, the scarce quantity of microscopic algae in the sample 1 may be due to the winter condition, but also caused by the stressing condition in the river water, probably to the high amount of suspended solids and the turbidity, where the diatoms are very sensitive (as photosynthetic plants). But the scarce number of diatoms in the three constructed ponds can be for sure due to stressing conditions there, heavy organic pollution, the high reductive conditions, due to high content of ammonium and nitrites, due to the instability of the new formed ecosystem.

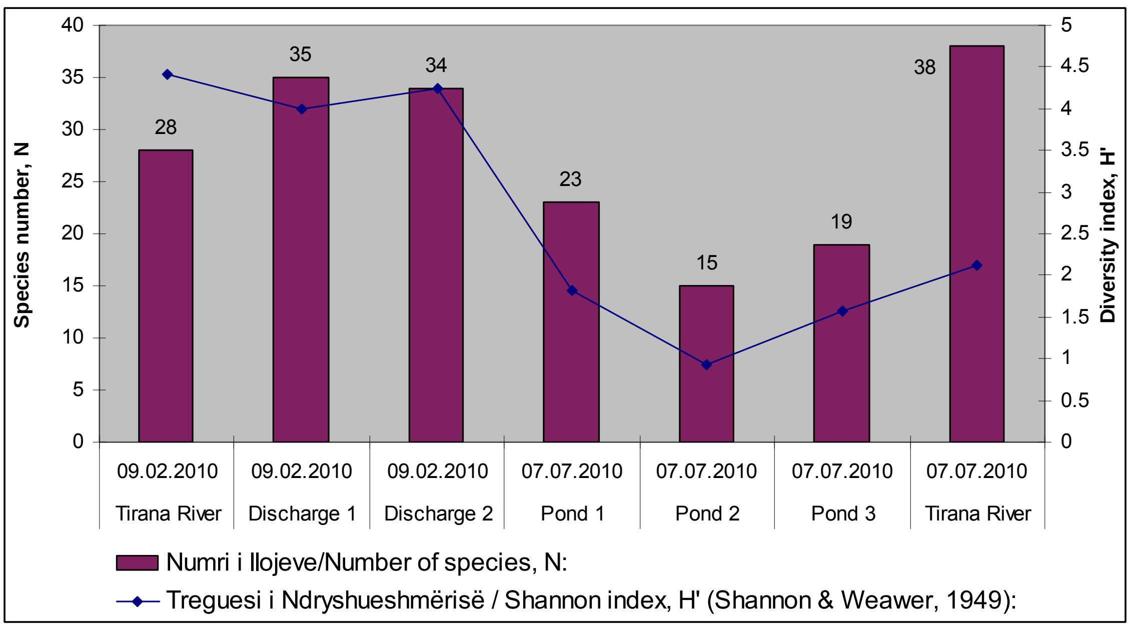

Figura 11. Number of diatoms species (N) and diversity index (H') calculated for the diatom community in two stations (Discharge 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the same data measured in three ponds (pond 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

With the calculated values of ecological indexes based on diatom communities there were shown even more differenced between two sampling tours (Tab. 8); saprobic index (SI) and trophic index of diatoms (TI_{DIA}) were higher in the three constructed ponds that in two original channels in February 2010 (Fig. 12), corresponding to Poly-hipertrophic or Polysaprobic (Klasa IV) state, respectively; but the index of pollution sensitivity (IPS), was the lowest ever calculated in Albanian Rivers (Miho *personal data)*, corresponding to bad quality. Compare the data in table 8 that the related state in February was much better, and more natural. Let us stress that after Prygiel &

Coste (1993) the IPS index shows strong correlations to organic pollution (BOD, COD, total N and particularly P), ionic strength (chloride, sulphates, conductivity) and eutrophication (chlorophyll and nitrates). It seems there were no much significant differences related with water trophy (quality) between three constructed ponds; it evidence strongly their bad state of water quality, probably caused form the unnatural state, instability of the wetland system. More or less, the same bad state was calculated even for the River itself, stressing even more the high risk its waters represent for the local inhabitants living in its riverbanks. The high trophic values of SI and TIDIA, corresponding to the low quality waters, were also found in other monitoring activities, in Lana, Gjola and Gjanica (Miho *et al.,* 2005; 2008).

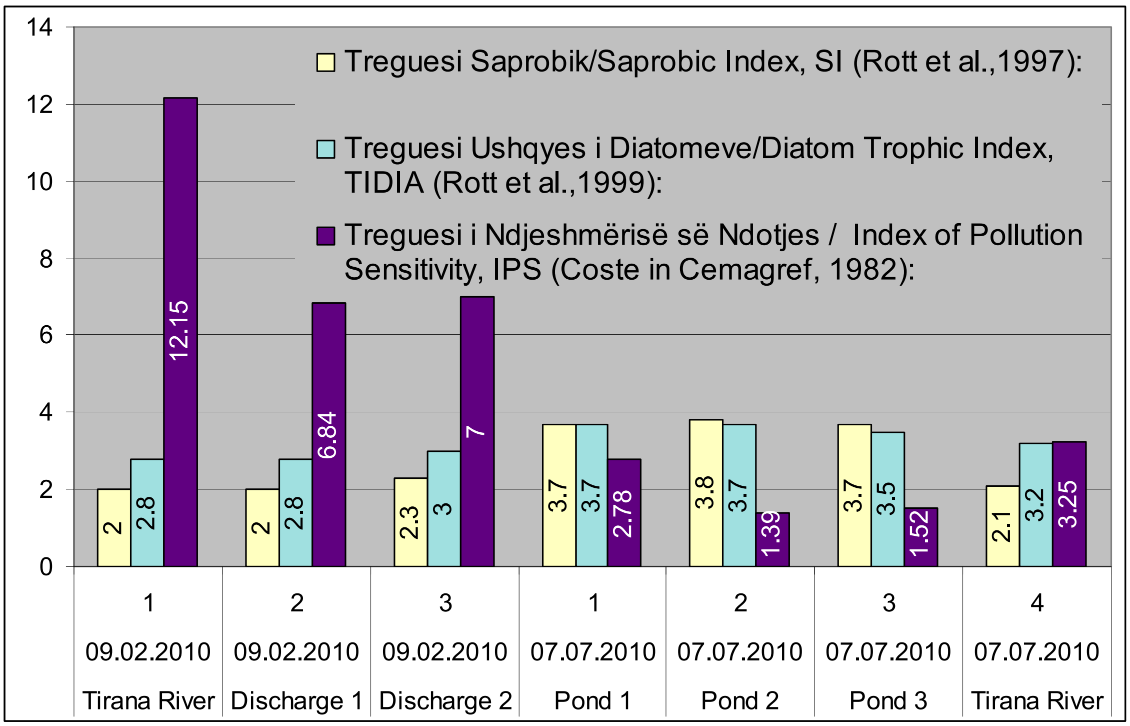

Figura 12. Saprobic index (S), trophic index of diatoms (TI_{DIA}) and index of pollution sensitivity (IPS) calculated for the diatom community in two stations (Discharge 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the same data measured in three ponds (pond 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

Table 7. Physico-chemical in general nutrients and microbiological data in two stations (Discharge 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the data measured in three ponds (pond 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010							
Station	**Tirana River**	**Discharge 1**	**Discharge 2**	**Pond 1**	**Pond 2**	**Pond 3**	**Tirana River**
Date	**09.02.2010**	**09.02.2010**	**09.02.2010**	**07.07.2010**	**07.07.2010**	**07.07.2010**	**07.07.2010**
Code	**1**	**2**	**3**	**1**	**2**	**3**	**4**
Physico-chemical in General							
Dissolved oxygen, DO mg/L	7.9	-	-	-	-	-	-
Dissolved oxygen, DO %	85.4	-	-	-	-	-	-
Water temperature, ˚C	9.1	-	-	28	29.3	26.8	27.3
Conductivity, µS/cm	476	332	-	746	613	552	551
pH	8.03	7.62	-	7.55	8.26	7.76	7.7
Total Suspended Solids, TSS mg/L	117.14	24.05	15.25	24.1	16.6	16.5	29.2
Nutrients							
Phosphates, P-PO_4^{3-}, µg/L	275	330.8	256.3	461.33	614.67	701.33	418.00
Ammonium, N-NH_4^+ mg/L	1.29	1.16	0.612	1.95	1.41	1.39	0.87
Nitrites, N-NO_2^-, µg/L	40.6	57.3	290.15	218	133.9	80.5	51.9
Nitrates, N-NO_3^-, mg/L	0.88	1.38	1.34	1.11	0.62	0.46	0.39
Phosphates, PO_4^{3-}, µg/L	842.88	1,013.90	785.56	1411.68	1880.88	2146.08	1279.08
Ammonium, NH_4^+ mg/L	1.66	1.49	0.79	2.51	1.81	1.79	1.12
Nitrites, NO_2^-, µg/L	133.57	188.52	954.59	716.29	439.96	264.5	170.53
Nitrates, NO_3^-, mg/L	3.9	6.11	5.93	4.93	2.76	2.05	1.75
Microbiological data							
Fecal coliforms, CFU/100 ml	25,000	26,000	22,000	25,500	22,500	20,600	21,800
Total coliforms, CFU/100 ml	26,000	28,000	24,000	27,000	20,500	21,000	22,300
Total heterotrophes in 28˚C CFU/100 ml	160,000	80,000	96,000	155,000	63,000	61,600	59,500
Total heterotrophes in 37˚C CFU/100 ml	360,000	400,000	300,000	302,000	292,000	205,000	189,000

Table 8. General data calculated for the diatom community in two stations (Discharge 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the data measured in three ponds (pond 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010

Station	River	Discharge 1	Discharge 2	Pond 1	Pond 2	Pond 3	River
River	Tirana						Tirana
Date	09.02.2010			07.07.2010			
Code	**1**	**2**	**3**	**1**	**2**	**3**	**4**
Numri i llojeve/Number of species, N:	***28***	***35***	***34***	***23***	***15***	***19***	***38***
Treguesi i Ndryshueshmërisë / Shannon index, H' (Shannon & Weawer, 1949):	**4.42**	**4.00**	**4.25**	**1.81**	**0.93**	**1.58**	**2.12**
Treguesi Ushqyes i Diatomeve/Diatom Trophic Index, TI_{DIA} (Rott et al.,1999):	**2.8**	**2.8**	**3.0**	**3.7**	**3.7**	**3.5**	**3.2**
Klasat ushqyese përaktëse / Relative trophic classes (Rott et al.,1999):	Eu-polytroph	Eu-polytroph	Eu-polytroph	Poly-hipertroph	Poly-hipertroph	Poly-hipertroph	Polytroph
Treguesi Saprobik/Saprobic Index, SI (Rott et al.,1997):	**2.0**	**2.0**	**2.3**	**3.7**	**3.8**	**3.7**	**2.1**
Klasat saprobike përaktëse / Relative saprobic classes (Rott et al.,1997):	Beta-mesosaprob (Klasa II)	Beta-mesosaprob (Klasa II)	Beta-mesosaprob to Alfa-mesosaprob (Klasa II-III)	Polysaprob (Klasa IV)	Polysaprob (Klasa IV)	Polysaprob (Klasa IV)	Beta-mesosaprob (Klasa II)
Treguesi i Ndjeshmërisë së Ndotjes / Index of Pollution Sensitivity, IPS (Coste in Cemagref, 1982):	***12.15***	***6.84***	***7.00***	***2.78***	***1.39***	***1.52***	***3.25***
Klasat përkatëse të Treguesit të Ndjeshmërisë së Ndotjes / Relative classes of the Index of Pollution Sensitivity, IPS (Coste in Cemagref, 1982):	**Mesatar / Moderate**	**Varfër / Poor**	**Varfër / Poor**	**Keqe / Bad**	**Keqe / Bad**	**Keqe / Bad**	**Keqe / Bad**

Table 9. List of diatom species and their percentile found in microscopic slides of periphyton samples the diatom community in two stations (Discharge 1 & 2), and in Tirana river in Bregu Lumit, measured in 09.02.2010, compared with the data measured in three ponds (pond 1, 2 & 3) of the new constructed wetland, and in the River, in 05.07.2010; the species that showed the abundance of more than 10% of the community are labeled with red.

Station	**River**	**Discharge 1**	**Discharge 2**	**Pond 1**	**Pond 2**	**Pond 3**	**River**
River	Tirana	Tirana	Tirana	Tirana	Tirana	Tirana	Tirana
Date	09.02.2010	09.02.2010	09.02.2010	09.02.2010	07.07.2010	07.07.2010	07.07.2010
Code	**1**	**2**	**3**	**1**	**2**	**3**	**4**
Emri i species/Name of species	p_i%	p_i%	p_i%	p_i%	p_i%	p_i%	p_i%
Centrales							
Cyclotella commensis Hustedt	**5.0**	**0.9**	**1.1**	**5.4**	**0.4**	**1.7**	**6.8**
Cyclotella cyclopuncta Hackansson				**0.9**	**1.1**	**0.2**	**0.6**
Cyclotella ocellata Pantocsek	**2.5**					**0.2**	
Stephanodiscus medius Håkansson	**16.3**	**1.3**	**5.9**	**1.9**	**0.2**	**0.2**	**0.2**
Stephanodiscus parvus Håkansson	**5.0**	**0.7**	**2.4**	**1.7**	**1.1**	**0.4**	**7.2**
Pennales							
Achnanthes catenata Bily & Marvan			**0.7**				
Achnanthes clevei Grunow var. Clevei							
Achnanthes coarctata (Brébisson) Grunov			**0.7**				
Achnanthes lanceolata (Brebisson) Grunow agg.		**1.1**	**0.4**				
Achnanthes lanceolata (Brebisson) Grunow agg. (ssp. ferquentissima)				**0.4**			
Achnanthes minutissima var. jackii Lange-Bertalot et Rupel		**7.3**	**4.9**				
Achnanthes minutissima Kützing var minutissima	**2.5**				**1.5**	**1.1**	**3.8**
Achnanthes minutissima var. saprophila Kobayasi & Mayama				**3.6**	**0.4**	**1.3**	
Amphora inariensis Krammer				**0.2**		**0.2**	
Amphora montana Krasske		**10.5**	**8.8**	**0.2**		**0.4**	
Amphora pediculus (Kützing) Grunow		**2.1**	**0.7**	**0.4**			
Caloneis bacillum (Grunow) Cleve				**0.2**			
Caloneis cf. bacillum (Grunow) Cleve		**0.3**					
Caloneis nov. sp.							**0.2**
Cocconeis pediculus Ehrenberg							**0.2**
Cocconeis placentula var. lineata (Ehrenberg) Van Heurck	**1.3**						**0.2**

Station	River	Discharge 1	Discharge 2	Pond 1	Pond 2	Pond 3	River
Cymbella (Encyonema) minuta Hilse		**0.1**					**0.2**
Cymbella (Encyonema) prostrata (Berk.) Cleve	**2.5**						
Cymbella (Encyonopsis) descripta (Hustedt) Krammer		**0.3**					**0.2**
Cymbella (Encyonopsis) microcephala Grunow gr.		**1.1**					
Cymbella affinis Kützing		**1.6**					**0.2**
Denticula tennius Kützing		**0.1**	**0.4**				
Diatoma ehrenbergii Kützing	**2.5**						
Diatoma mesodon (Ehrenberg) Kützing		**0.3**					
Diatoma moniliformis Kützing	**1.3**						
Diploneis ovalis (Hilse) Cleve							**0.4**
Fragilaria capucina var. *capitellata* (Grunow) Lange-Bertalot	**3.8**						
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot	**7.5**						
Fragilaria lapponica Grunow in Van Heurck (=Staurosirella lapponica (Grunow in VanHeurck) D.M.Williams & Round)			**1.3**				
Fragilaria ulna (Nitzsch) Lange-Bertalot agg.	**10.0**	**0.1**					
Gomphonema angustum (Kützing) Rabenhorst	**2.5**						
Gomphonema brebissoni Kützing		**0.3**					
Gomphonema minutum (C. Agardh). C. Agardh							**0.8**
Gomphonema olivaceum (Hornemann) Brebisson gr.	**2.5**						**0.2**
Gomphonema parvulum Kützing agg.	**2.5**		**0.4**	**0.2**		**0.2**	**0.2**
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	**3.8**	**2.1**					**0.4**
Gomphonema sp.			**0.7**				
Gomphonema tergestinum Fricke							**0.2**
Gyrosigma scalproides (Rabenhorst) Cleve							**0.2**
Hantzschia amphyoxys (Ehrenberg) Grunow	**1.3**	**3.7**	**5.3**	**0.2**		**0.2**	**0.2**
Navicula (Craticula) accomoda Hustedt			**0.7**				**2.7**
Navicula (Fallacia) insociabilis Krasske					**0.2**		
Navicula (Fallacia) monoculata Hustedt					**0.2**		
Navicula (Fistulifera) saprophila Lange-Bertalot & Bonik		**1.2**	**2.7**		**0.8**	**0.2**	
Navicula (Luticula) mutica Kützing	**2.5**	**2.1**	**0.5**	**0.4**	**0.8**		
Navicula (Luticula) muticopsis Van Heurck		**1.5**	**1.3**				

Station	River	Discharge 1	Discharge 2	Pond 1	Pond 2	Pond 3	River
Navicula (Luticula) nivalis Ehrenberg				**0.4**			
Navicula (Sellaphora) pupula (Kuetzing) Mereschkowsky		**0.3**					**0.2**
Navicula agrestis Hustedt			**1.5**				
Navicula asellus Weinhold ex Hustedt			**0.2**				
Navicula atomus (Kützing) Grunow			**1.3**			**0.2**	**2.8**
Navicula cincta (Erenberg) Ralfs				**0.4**		**0.2**	**0.2**
Navicula cryptotenella Lange-Bertalot							**0.4**
Navicula cryptotenelloides Lange-Bertalot	**2.5**	**0.3**					
Navicula erifuga Lange-Bertalot							**0.4**
Navicula gregaria Donkin				**0.2**			
Navicula oligotraphenta Lange-Bertalot et Hofmann							**0.2**
Navicula perminuta Grunow		**3.2**	**11.5**				**0.2**
Navicula reichardtiana Lange-Bertalot				**0.2**	**0.2**	**0.2**	**0.4**
Navicula rostellata Kützing							**0.2**
Navicula seibigii Lange-Bertalot		**3.7**	**4.6**				
Navicula sp.		**4.1**					**0.2**
Navicula tripunctata (O. F. Müller) Bory	**3.8**						
Navicula veneta Kützing		**2.9**	**3.3**				**1.1**
Nitzschia amphibia Grunow	**2.5**	**0.3**					
Nitzschia dissipata (Kützing) Grunow			**0.4**	**0.2**			**0.2**
Nitzschia hungarica Grunow		**0.3**					
Nitzschia incospicua Grunow	**5.0**	**13.9**	**6.2**	**2.1**	**0.4**	**0.2**	**0.2**
Nitzschia lacuum Lange-Bertalot		**3.4**		**0.9**		**0.4**	
Nitzschia linearis (Agarth) W. Smith var. *linearis*		**0.3**	**0.2**				
Nitzschia linearis var. Subtilis (Grunow) Hustedt	**2.5**						
Nitzschia palea var. debilis (Kützing) Grunow							**0.2**
Nitzschia palea (Kützing) W. Smith var. *palea*	**1.3**	**21.4**	**5.3**	**4.9**	**5.5**	**50.8**	**67.4**
Nitzschia cf. pusilla (Kützing) Grunow			**15.9**				
Nitzschia sinuata var. delognei (Grunow) Lange-Bertalot				**1.7**	**0.2**		
Nitzschia sp. 1			**6.8**				
Nitzschia sp. 2	**1.3**	**6.8**	**2.0**				

Station	River	Discharge 1	Discharge 2	Pond 1	Pond 2	Pond 3	River
Nitzschia umbonata (Ehrenberg) Lnage-Bertalot				**73.0**	**87.1**	**41.5**	**0.4**
Pinnularia borealis var. rectangularis Cralson	**2.5**		**0.9**				
Pinnularia microstauron var. brebissonii (Kützing) Mayer			**0.4**				
Rhoicosphenia abbreviata (Agardh) Lange-Bertalot	**2.5**						
Rhopalodia brebissonii Krammer							**0.2**
Surirella angusta Kützing	**1.3**	**0.7**	**0.7**				
Surirella bifrons Ehrenberg							
Surirella brebissonii Krammer & Lange-Bertalot							**0.4**

Conclusions

Concluding we may confirm that the place **Bregu Lumit continue to be an excellent model of a highly polluted part of the River Tirana**, with extremely high values of several parameters, form the nutrients (nitrogen and phosphorous), to the microbiological data and periphyton community. Beside the very ugly scenery that this river part show in Tirana capital, the bed quality of waters are very harmful to the water biota, but also to the human community living along the river banks and elsewhere. The bad situation is accumulated downstream the river, with synergic effects, collecting even more nutrients and other pollutants that increase further its harmful impact in Gjola and Ishmi, and for sure in Ishmi delta (Rodoni bay and Patoku lagoon). Çullaj et al. (2005), Miho *et al*. (2005; 2008) confirm that the water of Tirana River is of the first quality in its upper part in Zall Dajti village, but its quality is heavily changed soon after Brari village, when the river is approaching the Tirana town, transformed in a simple collector of solid and liquid waste, and exploited also for gravel mining.

Considering the physical-chemical parameters, microbiological and biological ones, assessed by us during two sampling tours, it can be confirmed that there is **some slight progress of water treatment crossing through three biological ponds of the new constructed wetland**; but, it is weak and not very significant for the heavy pollution in the area. The **new wetland is still in an unstable state**, far to the natural state. We have the opinion that **it will need some time, probably few years, that the wetland to get its normal function in phytoremediation of the waste water**. Nevertheless, the wastewaters from Tirana cannot be treated through small spots of wetland, like that build up in Bregu Lumit; the water treatment using constructed wetland system is quite spread out around the world, but **only in decentralized water treatment**, in isolated settlements or other activities, not in big towns, with a heavily pollution, like Tirana.

The project "Constructed Wetland for Nutrient Reductions in the Waters of Tirana River in Albania", run by the Institute for Environmental Policy (IEP; http://www.iep-al.org/), in partnership with Ekolëvizja and Tirana Municipality, **was an alarming signal for Albanian society, and moreover for Tirana capital to consider the water quality as an important measure to protect the quality of life**. Building up an artificial wetland, just there where is **the core of the heavy pollution**, is very significant. Not for the fact that through this somehow modest activity the pollution in Tirana River will be solved really; but it probably was **an additional bell to tell and evidence how bad the situation is there**. We can confirm that it is not only there so extremely bad; the same situation is also all along Tirana, Lana and Ishmi rivers, crossing through Tirana town. In this way they all represent an everyday risk for the human health, and for the biota along the rivers and on Ishmi see delta; these rivers, represent also an ugly image of the actual development of the region.

Tirana metropolis, with ambitious progress during the last two decades, cannot continue the development with two open wastewater channels, such as Tirana and Lana rivers. We strongly support that the **collecting of wastewater in separate collectors either along Lana or along Tirana River would be an urgent priority.** It means, first, building up an effective **Collecting System in Tirana**, which collects and conducts urban waste water to an **Urban Waste Water Treatment Plant**. At least '**primary treatment'** of collected waste waters is strongly recommended; it means the physical and/or chemical process, involving settlement of suspended solids, or other processes in which the BOD5 of the incoming waste water is reduced by at least 20% before discharge and the total suspended solids of the incoming waste water are reduced by at least 50%, as it is specified in EU Directive 91/271 (21 May 1991) concerning urban waste water treatment (http://eur-lex.europa.eu/LexUriServ/site/en/consleg/1991/L/01991L0271-19980327-en.pdf). But the quality of water would be solved with a '**secondary treatment'**, generally involving biological treatment with a secondary settlement or other process, in which the waters reach the requirements established in the table 1 of annex 1 of EU Directive 91/271.

Cited literature

2006/44/EC Fish Directive: Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life. Official Journal of the European Union. 264/20—264/31 http://rod.eionet.europa.eu/show.jsv?id=626&mode=S

APHA/AWWA/WPCF (1995): Standard Methods for the Examination of Water and Wastewater 19th Edition, American Public Health Association, Washington, D.C.

Cemagref (1982): Étude des méthodes biologiques d'appreciation quantitative de la qualité des eaux. Rapport Q.E. Lyon - Agence de l'Eau Rhône-Medtierrane Corse. 218p.

Cullaj A., Hasko A., Miho A., Schanz F., Brandl H., Bachofen R. (2005): The quality of Albanian natural waters and the human impact (Review article). Environment International 31: 133-146

EN 13946:2003: Water quality. Guidance standard for the routine sampling and pretreatment of benthic diatoms from rivers. ISBN 0 580 41960 6; Pages 18. http://standards.mackido.com/en/en-standards24_view_3175.html

EN 14407:2004: Water quality. Guidance standard for the identification, enumeration and interpretation of benthic diatom samples from running waters. ISBN 0 580 44247 0: 1-16 http://www.standardsdirect.org/standards/standards1/StandardsCatalogue24_view_11733.html

EU Directive 91/271 (1991): Urban waste water treatment. 1-16 (http://eur-lex.europa.eu/LexUriServ/site/en/consleg/1991/L/01991L0271-19980327-en.pdf).

HACH (2001): Portable Multiparameter Meter Sension 156, Manual, Cat. No. 54650-18

Hysko M. (2007): Manual i Mikrobiologjisë. FShN, UT.

ISO 5667-6:1990: Water quality - Sampling - Part 6: Guidance on sampling of rivers and streams

ISO 6222:1999: Water quality - Enumeration of culturable micro-organisms - Colony count by inoculation in a nutrient agar culture medium

Krammer K., Lange-Bertalot H. (1988-2005): Suesswasserflora von Mitteleuropa. In: Ettl H., Gerlof J., Heynig H. and Mollenhauer D. (eds), Fischer, Stuttgart & Jena: 2/1 (2001): 1-876; 2/2 (1988): 1-596; 2/3 (1991a): 1-576; 2/4 (1991b): 1-437; 2/5 (2005): 1-311

Miho A., Kupe L., Jaupaj O., Karjalainen S. M., Hellsten S., Pritzl G. (2008): Overview of Water Quality of Albanian Rivers. The Third International Scientific Conference BALWOIS 2008, Ohrid, Mk, 27-31 May 2008. http://balwois.com/balwois/administration/full_paper/ffp-969.pdf

Miho A., Cullaj A., Hasko A., Lazo P., Kupe L., Schanz F., Brandl H., Bachofen R., Baraj B. (2005): Gjendja mjedisore e disa lumenjve të Ultësirës Adriatike Shqiptare / Environmental state of some rivers of Albanian Adriatic Lowland. SCOPES program (Swiss National Science Foundation - SNSF), Tirana (In Albanian with a summary in English): 1-267 http://www.unitir.edu.al/doc/fshn/ALB-RIVERS-WEB-PDF/000a-ALBRIVERS-Pasqyra-Content.htm

Miho A., Çullaj A., Bachofen R. (Eds.) (2009): Bovilla(Albania) – Limnological Study / Studim Limnologjik. FShN, University of Tirana: 1-350 http://www.unitir.edu.al/doc/fshn/BOVILLA(Albania)-WEB-PDF/000-0BOVILLA(Albania)-Pasqyra-Content.htm

NEA/AKM (Ed.) (1999): Albania: Convention on Biological Diversity. Biodiversity Strategy and Action Plan (National Report), National Environmental Agency (NEA), Tirana. 1-100 http://planet.uwc.ac.za/nisl/Biodiversity/pdf/al-nbsap-01-en.pdf

Prygiel J., M. Coste (1993): The assessment of water quality in the Artois-Picardie water basin (France) by the use of diatom indices. Hydrobiologia, 269/270: 343-349.

Rott E., Hofmann G., Pall K, Pfister P., Pipp E. (1997): Indikationslisten für Aufwuchsalgen in Fließgewässern in Österreich. Teil 1: Saprobielle Indication. Projekt des Bundesministeriums für Land- und Forstwirtschaft, Wasserwirtschaftskataster: 1-80

Rott E., Pipp E., Pfister P. (2003): Diatom methods developed for river quality assessment in Austria and a cross-check against numerical trophic indication methods used in Europe. Algalogical Studies 110 = Arch. Hydrobiol. Suppl. 149, Stuttgart: 91-115

Rott E., Pipp E., Pfister P., Van Dam H., Ortler K., Binder N., Pall K. (1999): Indikationslisten für Aufwuchsalgen in Österreichischen Fließgewässern. Teil 2: Trophieindication. Bundesministerium für Land- und Forstwirtschaft, Zahl 41.034/08-IVA 1/97, Wien: 1-248

Shannon C. E., Weawer W. (1949): The mathematical theory of communication Univ. Illinois Press, Urbana.

Tockner K., Uehlinger U., Robsinson C.T. (Eds) (2009): Rivers of Europe. Academic Press. 700 pages.

Troendle C. A. (2002): Albanian Watershed Assessment. MATCOM Corporation. Fort Collins, Colorado. USA, 1-68 http://www.fs.fed.us/institute/albania/albania_watershed_assess.pdf

Zelinka M., Marvan P. (1961): Zur Praezisierung der biologischen Klassification der Reinheit fliessender Gewaesser. Arch. Hydrobiol., 37: 387-404

IPM & Ekolevizja (Eds.) (2010a): Brochure (in Albanian) introducing the project results

IPM & Ekolevizja (Eds.) (2010b): Leaflet (in Albanian) introducing the project and the constructed wetland http://iep-al.org/docs/wetland_leaflet_web.pdf

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