Living Water Exchange Project – Albania
Site visit and project review report

Constructed Wetland for Nutrient Reductions in the Waters of the Tirana River in Albania

November, 2010

Overview: This project was centered on the development and evaluation of a constructed wetland system along the banks of the Tirana River within the municipality of Tirana, the capital of Albania. The project was led by the Institute for Environmental Policy NGO but also involved scientist from Tirana University. Samples from what appear to be two combined sewer outfall pipes (combination of sewage and urban runoff) and the Tirana River were take in February 2010 and analyzed for various pollutants and biological parameters. In the spring of 2010, a constructed wetland consisting of three adjacent 5m by 25m basins were built. The basins were designed so that influent from the pipes could enter the first basin and then would overflow into the second basin which would again overflow into the third basin. The wastewater was discharged from the third basin into the Tirana River. In concept, particulate matter would settle in the first basin, treatment would occur in the second basin and “polishing” or further treatment would occur in the third basin, prior to discharge. The basins were planted to various wetland plants. Cattails were observed to be the dominant species in the wetland basins during a 15 September 2010 site visit. The three basins and the river were sampled again for pollutants and biological parameters in July 2010 after the cattails were reasonable well established.

The location of the site was selected and provided by the Municipality of Tirana in an area known as “Bregu Lumit”. The site was located in a filled area of floodplain on which unpermitted houses had and are being built, and the river bank, including the wetland area was used for illicit disposal of garbage and solid waste (Photo 1). Volunteers from environmental NGOs removed the solid waste from the site prior to constructing the wetland. This just moved the illicit dumping immediately upstream of the wetland as will be discussed later. After the site was constructed, two new unpermitted houses were built on filled land adjacent to the wetland (one was still under construction in September 2010 (Photo 2)). The unpermitted houses built on the filled floodplain appear to have shallow wells for their domestic water supply, which will also be discussed later.

The principal activities with this project involved the construction of the wetland, two water sampling and analysis events to estimate water quality impacts in the first year and some outreach. The primary outreach efforts appear to have been to officials from the city of Tirana.

Photo 1: Conditions along Tirana River at constructed wetland site


Photo 2: New houses adjacent to constructed wetland on filled floodplain

Overall Comments on Project

The project team is to be commended for what they were able to accomplish in the short time provided by project funding. Getting agreement from Tirana Municipality on a site, removing all the solid waste and constructing the concrete walls for the basin in time to successfully establish the cattails required a tremendous amount of effort by the local environmental community. It was clear during the site visit that Edvin Pacara, with the Institute for Environmental Policy, had provided the energy and leadership to get the project implemented in such a short time frame.

Performance of constructed or restored wetlands:

General: Constructed and restored wetlands have proven to be very effective at nitrogen, phosphorus and sediment removal when properly constructed and managed. Such wetlands have been used to remove nutrients from wastewater, agricultural runoff and stormwater runoff in numerous studies and applications around the world. Their potential is far greater than the limited use seen to date but they must be appropriate for the situation in which they are placed to be effective. They are generally used either to treat small wastewater flows or intermittent runoff flow from agricultural or developed lands. The most important factors in their performance are the residence time of the water in the wetland and contact of the water with vegetation and wetland substrate so that ample opportunity exists for treatment. As stated in their second report from July 2010, it may take several years for a constructed wetland to reach its full potential. Since these plants had less than six months to grow, only limited impacts could have been expected under the best of circumstances. Despite the limitations discussed below, water exiting the wetland was notably clearer than what entered (Photos 3 and 4).

Photo 3. Wastewater near influent pipe

Photo 4. Discharged water from wetland

Observations and Recommendations on the Tirana River Constructed Wetland Project

<u>Observation:</u> *Size and function of the constructed wetland:* The wetland appears far too small for both the hydraulic and pollutant loads that entered it from the two pipes. As shown in Figure 1, residence time of the water is critical for nutrient removal from a constructed wetland. Figure 1 shows results for phosphorus removal but results would be similar for nitrogen. It is apparent from Figure 1 that a water residence time of 3-7 days is needed to get optimal levels of removal (where the slope of the removal curve “flattens out”).

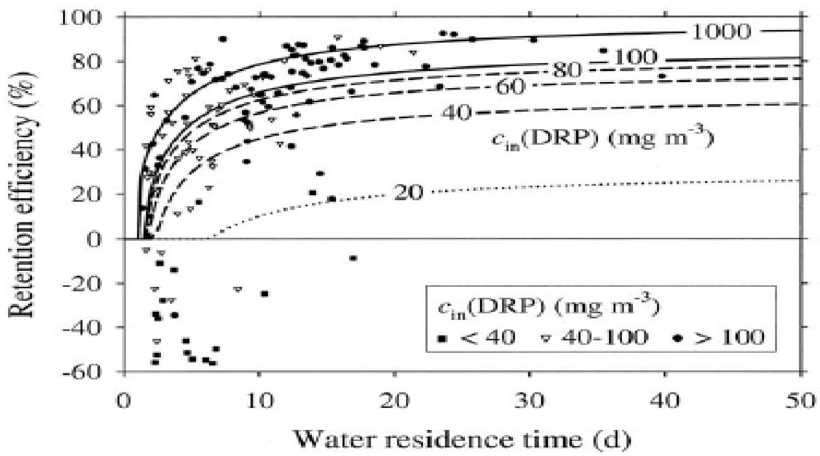

Figure 1: Removal of dissolved reactive phosphorus (DRP)
in a wetland as a function residence time

There was no measurement of flow into the wetland but several people with hydrologic experience, including the author, estimated it to be in the range of 0.2 to 1 cubic meter per second (cms) based on observation at both the influent and effluent points. If one assumes a half meter of water in the 375m^2 wetland (which would be deep for a vegetated wetland), the residence time of the water is between about 3 and 15 minutes. While this may be adequate for some settling and limited nutrient removal by biomass, the residence time is so short that only limited treatment could ever be expected from such a small wetland receiving such a proportionally large volume of water. If the flow is 0.5 cms, it would take an area about 300 times the size of this wetland, about 10,000 m^2 or one hectare, to provide near optimal treatment, *if designed the same as this wetland*. While this wetland had three cells or ponds and there appears to be shallow submerged baffles in the basins, the system was severely undersigned for the flow received.

<u>Recommendation 1:</u> Wetland design for efficient treatment: Wetlands can be designed to increase efficiency and residence time so that flows of this magnitude could probably be treated to remove nutrients and sediments with about 2500 to 5000 m^2. The increased efficiency could be obtained by creating a circuitous (highly meandering) flow path through the wetland area using baffles, islands, rocks, vegetative barriers, etc to maximize retention time within the cell and also maximize interaction of the water with vegetation and wetland substrate (soil and organic material base).

<u>Recommendation 2:</u> Wetland modification and management: Even if the wetland was designed for optimum residence time and interaction with vegetation and substrate, the current wetland is too small for the flow entering it. Either the flow needs to be reduced to less 10% of current flow (preferably less than 5% or the wetland needs to be expanded in size to 2500 to 5000 m^2 (which is unlikely given the location and ongoing construction occurring). If the wetland is going to be maintained at its current size after the project, at a minimum, the pipe with the largest flow should be diverted from the wetland. While it is recognized this will directly discharge that wastewater to the Tirana River, it is necessary to give the wetland any reasonable opportunity to reduce nutrients or suspended solids (inorganic and organic particles). All wastewater should be redirected from the wetland for a short period to allow redesign of the wetland base to

assure more circuitous flow and better interaction with vegetation and substrate. This can be done by improving the baffle system and/or creating “rock pile” diversions or flow directors. The above water line vegetative biomass should be harvested at least once per year. Those working on the wetland or harvesting biomass should take adequate precautions to protect themselves from exposure to the untreated sewage in the wetland.

Observation: *Monitoring of the wetland:* The short time period for the project limited the opportunity for monitoring influent and effluent water quality, however, only two sampling dates were reported; pre-construction and post-vegetation establishment. The first set of samples was from the pipes and the river in February and the second set was from each of the three basins and the river in July. While understandable due to project time constraints, the results are inadequate to draw any meaningful conclusions about function of the wetland. Some parameters appear to go down while others, such as PO^4 (phosphate) appear to increase.
Recommendation: Assuming continued evaluation of the wetland (and flow or size modification), sampling needs to occur at a monthly to quarterly frequency and the parameters of greatest interest and importance should be focused upon. Total nitrogen was not determined in the two samples and it is likely that large amounts of dissolved and particulate organic nitrogen may be entering (and leaving?) the wetland. Also, there was much work done on the biotic community in the wetland and river. While important, and of academic interest, the focus of water monitoring at this time should be on key pollutants and the wetland‘s effectiveness at reducing them. These would include total phosphorus, PO^4, total nitrogen, ammonium, nitrite, nitrate, suspended solids and fecal and total coliform.

The other key monitoring element that was missing was flow into and/or out of the wetland. As discussed above, no flow data was available and tour group members made rough estimates of flow based on their experience. Flow from the two pipes should have been measured before designing the wetland and should be measured at least monthly, if not possible to have continuous flow measurement. A weir can be constructed on each pipe and flow can be calculated based on the height of flow through the weir. The weir should be designed to allow flow estimation at both low (summer) and high (winter) flow levels. A continuous flow monitoring device would be preferred but may not be economically feasible and would also have a high probability of damage by vandalism.

Observation: *Treatment of municipal wastewater in a constructed wetland*: Flow to the wetland was from two pipes that appeared to represent household wastewater and sewage and perhaps stormwater runoff, although the amount of flow stormwater is unclear. Based on the project report and site visit, it is assumed most flow is from municipal wastewater. Allowing stormwater flow into this system would overwhelm and probably damage the wetland. There was no evidence of this but the source of flow does need to be determined.

Constructed wetlands are used very effectively to reduce nutrients and suspended solids from municipal wastewater *but usually only after at least primary treatment and disinfection*. The wetland has limited chemical or biologic ability to kill pathogens in wastewater. The vegetation and substrate will filter some pathogens and provide modest reductions before discharge but will not make the water safe for human contact.

Recommendation: It is not feasible to do primary treatment and disinfection on just the flow to this site. It is acknowledged that the removal of even modest amounts of pathogens is some improvement from previous conditions, however, constructed wetlands cannot make the waters of the Tirana River safe for human contact. As discussed below, it is questionable if constructed wetlands are appropriate for treating wastewater for nutrients and suspended solids from cities the size of Tirana, and they will clearly not accomplish needed disinfection.

In their July report, the project team acknowledges that such wetlands cannot treat the flow for Tirana and that some form of centralized sewage treatment is needed. While that may not be possible at this time, it is the only means, of which I am aware, to make the waters of the Tirana River and downstream estuaries, safe for human contact. Based on further reading, towns above Tirana will also need treatment to kill pathogens. It is critical that both the municipal and national governments understand that c*onstructed wetlands are not intended to provide disinfection*.

Observation: *Appropriate flows for wetland treatment:* Constructed or restored wetlands require sufficient land area if they are to be effective that they are typically only used to remove nutrients and suspended solids for flows from smaller towns and cities with flows of less than 4,000 cubic meters per day. It is difficult to directly relate this to a population size since it is a function of industrial discharges and other sources but it is unlikely that constructed or restored wetlands would be the most economically feasible option for cities with more than 50,000 people. Regardless of population base; collection, primary treatment and disinfection are assumed to occur before running the wastewater through the wetland for nutrient and suspended solid removal.

Recommendation: As the project team acknowledges in their July report, constructed wetlands are not likely to be a viable option for nutrient or suspended solids removal for a city the size of Tirana due to the large land area required. Smaller wetlands could help remove nutrient and solids but would need primary treatment and disinfection before discharge to the wetlands. Building many small treatment plants is usually not cost effective. The project wetland can continue to function as a demonstration and research site (with some of the adjustments noted above) but it should be made clear that wetlands are not likely to be the solution for wastewater treatment for nutrient, suspended solids or pathogens for the municipality of Tirana. The information collected at the demonstration site could assist smaller communities in Albania and throughout the region who wish to implement constructed wetlands (however, as noted below, general conditions at the site may not make it a desirable location for a long term demonstration).

General recommendations on appropriate application for constructed and restored wetlands to remove nutrients or suspended solids.

There are four primary situations in which wetlands, when properly designed and operated, can be very efficient at nutrient and suspended solids removal. The first two situations are for treatment of flows from small to medium towns and for treatment of non-toxic industrial discharges. These usually have reasonably consistent flow rates so a wetland treatment system similar to the one used in this project and designed and operated to handle the flow and total nutrient and suspended solids loads could be efficient and cost effective. Again, it will not provide pathogen removal or disinfection at needed levels.

The other application of constructed or restored wetlands that was not the focus of this project would be to treat storm water runoff or drainage flow from agricultural or urban catchments. There are numerous examples of such wetlands that could provide guidance on their design and efficiency. When properly designed, constructed, operated and maintained, they can be very effective, however, they must be designed and managed differently. Unlike wastewater discharges which are relatively uniform in flow, runoff and drainage varies from nil to extremely high flows during the course of a year. As a result, some open water retention basin is usually require to allow capture of runoff from a “design storm” (usually 1-5 year return frequency) and the subsequent distribution of that water over time through the associated wetland. The other difference is that runoff treatment wetlands can go through prolonged periods where no water will enter the system. It is critical to design the wetland treatment system so that it maintains it wetland function through such dry periods or can rapidly recover when water enters it following rainfall events. Constructed wetlands have been used successfully in many locations for diffuse pollutant control. Constructed or restored wetlands may have their greatest application as the final component of a multi-step treatment system that reduces nutrient and suspended solids in runoff from diffuse sources.

Closing observations on the Tirana River riparian corridor

The area of the Tirana River observed during the site visit has so many issues of concern that it was hard for the tour group to even focus on the wetland and the potential benefits of constructed wetlands. Most of the natural floodplain and wetlands along the river had been, or were being, filled with spoil material, apparently as a convenient dumping ground for excavated material. (Photo 5). Fill material was even being pushed into the river to change its water course (Photo 6). The riverbed and bank had become a dumping ground for household and construction solid waste (Photo 7). The fill, with solid waste included, was flattened and unpermitted houses had been, and were being, built on the filled floodplain area (Photo 8). Shallow wells had been bored through the fill to provide water, likely highly polluted with pathogens and chemicals, for the unpermitted houses (Photo 9). This had been ongoing long enough that a community had developed within the floodplain and further filling was occurring which was leading to expansion of the illicit community on the floodplain.

Photo 5: Fill and solid waste along Tirana River

Photo 6: Fill changing flow path of Tirana River


Photo 7: Solid waste disposal along banks of Tirana River


Photo 8: New unpermitted house being constructed on fill in Tirana River floodplain

Photo 9: Shallow well in floodplain fill

Closing comments on the condition of the Tirana River in the City of Tirana

The Tirana River was milky colored, filled with debris and had high pathogen and nutrient levels according to sample results. It was clearly not safe for human contact and it seems unlikely it could support fish or other healthy aquatic communities. In addition, filling of the floodplain and wetlands will cause more severe flooding downstream.

Collection and treatment of sewage appears to be a paramount need in Tirana, however, it is clear that riparian zone management, solid waste management and the discontinuation of filling and building on the floodplain and wetlands are equally essential to the protection of public health and improvement of quality of life and civil society.

The small wetland demonstration site will not restore the Tirana River but continuing to take municipal, national and international officials to see it should awaken all of those visiting to the horrific conditions along the Tirana River as it flows through the capital city bearing its name on the way to the Adriatic Sea.