HISTORY, HYDROLOGY AND ECOLOGY OF BALILI RIVER, LA TRINIDAD, PHILIPPINES

Jones T. Napaldet and Inocencio E. Buot Jr.

Received: 13.08.2019 / Accepted: 24.10.2019

Abstract: This study documented the history, hydrology and ecology of Balili River as part of its rehabilitation efforts. Balili River, historically, is the cradle of civilization in La Trinidad, Benguet. It started as a small creek, but was widened becoming the main drainage in the valley. The river was pristine up to Japanese times, though with urbanization of La Trinidad and Baguio City, it became severely polluted. Previous study revealed that the river was most polluted near Baguio City and improved downstream but this trend has no longer been observed in recent data, indicating several sources of pollutants from La Trinidad itself. The river has recorded very high BOD, nutrient load, coliform and lead beyond the permissible levels. Its polluted state is also reflected in its biodiversity, currently dominated by organic pollution-associated algae, common weeds and mosquito fish. Several efforts have been exerted to rehabilitate the river but it is still polluted. This could be partly attributed to the limited and lack of in-depth scientific studies on the river.

Keywords: Balili River, La Trinidad, water quality

Introduction:

Balili River is an important water resource of Baguio City and La Trinidad both historically and economically. Like most urban rivers, Balili River suffers from heavy pollution due to various human activities including indiscriminate waste disposal. It is classified as Class A by Environmental Management Bureau (EMB-CAR), nonetheless it is practically a dead river during summer months. The excessive pollution of the river is usually blamed on the densely populated city of Baguio, with the river previously being tagged as “toilet bowl of Baguio City”. A study by the City Environment and Parks Management Office (CEPMO 2013) of Baguio City shows that half of the city's population lives within the Balili watershed area, contributing the most waste. The river was included in the DENR's 2003 Pollution Report as one of the 15 "biologically dead" rivers among the 94 principal river basins in the country (Aro 2011; Palangchao 2011).

The pollution issue of Balili River was documented as early as 1970’s (Mamoyac 1970) and the rehabilitation efforts starting as early April 1999 with the launching of Balili River Summit. With these, it is expected that a robust data on Balili River would be readily

Jones T. Napaldet
Biology Department Benguet State University
La Trinidad,
Benguet 2601
e-mail: jtnapaldet@up.edu.ph

Inocencio E. Buot Jr.
Institute of Biological Sciences
University of the Philippines Los Baños
Faculty of Management and Development Studies
University of the Philippines Open University
Los Baños, Laguna, Philippines 4031
e-mail: iebuotjr@upou.edu.ph

available, this may not be the case. Only a handful of published articles about the state of the river are available. The majority are gray literature such as undergraduate theses, monitoring and terminal reports, news articles and others. Thus, this study aims to summarize and compile these data to provide baseline information on the history, hydrology and ecology of Balili River. It is hoped that presenting these data into the scientific community by making them readily accessible, it would help, in a way, rehabilitate the river.

Materials and methods:

Secondary data have been secured from different agencies that regularly monitor Balili River such as EMB-CAR and CEPMO Baguio. The unpublished theses about Balili River were also collected from Benguet State University and University of the Philippines Baguio. Historical data on Balili River were gathered from La Trinidad and Baguio City Socio-Economic and Physical Profiles and from Philippine Information Agency. The published articles on Balili River were also secured. The data gathered from these sources were reviewed, compared and summarized to present a historical, hydrological and ecological view of Balili River and its implication to society.

Considering the water quality of Balili River, the data used were primarily from the study of Abedania et al. (1990) and from the regular water quality monitoring of EMB-CAR. This agency started monitoring the water quality in the early 2000s, but the data they were able to provide pertained to the years 2011-2016 only. In order to come up with a time series presentation of water quality, the four stations used by Abedania et al. (1990) were reconciled with the stations used in EMB-CAR monitoring. These stations were selected to present the changes in water quality as it flows away from Baguio City, the major source of pollutants. Station 1 is at km 3 Bell Church, where all the tributaries coming from Baguio City converge into Sagudin Creek; Station 2 is at km 4, La Trinidad; Station 3 is at km 5 near Balili Bridge, while Station 4 is at km 6 under Capitol Bridge. Also, water quality at different times of the year was as well acquired, summarized into Quarters (Q) 1, 2, 3 and 4 since water quality fluctuated with the season primarily due to dilution from rain.

Results and discussion:

Balili River History and Society

The history of Balili River has intricately been woven with La Trinidad since the cradle of civilization in the area started along the bank of this river. Originally, La Trinidad valley is a swampy area with no natural drain, locally termed as ‘benguet’ meaning lake. This term eventually became the name of the province (La Trinidad Socio-Economic and Physical Profiles 2014). Balili River is named after Barangay Balili, which it traverses. The name Balili was coined from the local term ‘badili’ which refers to the tall grasses common in the area that were previously used to bundle firewood, sayote and camote tops for market. When Kankana-eys migrated in the area, it was difficult for them to pronounce ‘badili’, instead mispronouncing it as ‘balili’ (Barangay Balili Physical and Socio-Economic Profile 2014).

Before the Spanish Period, there were already Ibaloy settlers usually dwelling along the river. The river provided water for domestic use and irrigation of their farms. The Ibaloys were known to have built their houses within their farm. Apart from these, the river used to supply food to the settlers including edible flora such as taro (*Colocasia esculenta*), ‘pako’ (*Diplazium esculentum*) and bagyu (algae) and edible fauna such as ‘bonog’ (*Glossogobius circumspectus*), ‘paideng’ (*Pseudogobius javanicus*), yoyo (*Misgurnus anguillicaudatus*), igat (*Anguilla* sp.), moonfish, frogs and shells (BRSRC 2012). During those times, the river was crystal clear so that bathing, swimming and washing clothes were common activities in the river.

During Spanish period, the first account on La Trinidad was forwarded by Don Q.M. Quirante in 1624 but it is only after a century that an expedition led by Galvey discovered the valley in 1829 and established a settlement. The trails of Balili River were followed in establishing that community. Relatively the most developed settlement in Benguet area, La Trinidad served as the gateway to the southern lowlands and the centre of administration to the Spaniards. The main vegetables produced by the people then were 'kamoteng kahoy', 'camote', 'gabi', beans and tomatoes. Rice was grown only to make 'tapey' or rice wine, which was used for ceremonial purposes in 'cañao'. The Spaniards introduced corn, coffee and tobacco. It was also during the Spanish period that the Balili River was widened and opened up to minimize flooding of the swampy area during rainy season.

La Trinidad, during the American Period, boomed as a commercial producer of vegetables when the irrigation system in central part of La Trinidad was constructed. An experimental farm school (now Benguet State University) was founded in 1910 focusing on viability testing of American vegetables such as cabbage, lettuce and strawberry. Also, a mulberry plantation was established to support the silk industry owned by Joaquin Elizalde. A slaughter house near Balili River was also constructed. Nonetheless, the river is still teeming with native fishes, though exotic fish species such as *Micropterus salmoides* were also introduced in the river (Butler 2006). The river also served as site for swimming and fishing parties for entertainment and recreation of families.

During the brief occupation of the Japanese, La Trinidad continued the commercial production of temperate vegetables such as beans, peas, carrots, tomatoes, beets and cabbage. The Japanese also introduced exotic fish species such as gold fish (*Carassius auratus*). It was also during this time that yoyo proliferated not just in the area but throughout the entire Cordillera, hence being tagged as Japanese fish. During the liberation, La Trinidad served as major battleground, especially the northern part of Balili River, where the defence posts of the Japanese were strategically located.

After the war, La Trinidad and the nearby Baguio City started to rise from the ashes of war. These areas become the centre of commerce and major industries in the region such as the vegetable industry. La Trinidad started from a sleepy town, then emerged as a first-class urban municipality and centre of education, marketing and trading for the province of Benguet. With that came the fast-rate urbanization and major immigration waves of people from the neighbouring towns and lowlands. The population of La Trinidad was 267 in 1903; 7,994 in 1948; then it ballooned to 67, 963 in 2000 and 107,188 in 2010 (La Trinidad Socio-Economic and Physical Profiles 2014). With this rapid increase of population appeared environmental problems such as the pollution of Balili River. Refer to Figure 1 (see Annexes) for the historical transformation of Balili River through time.

Several efforts have been exerted to rehabilitate the river. The first activity documented was the launching of Balili River Summit in April 1999. This was followed by different activities such as clean-up drives, information campaign etc. until finally establishing Balili River as a Water Quality Management Area in 2015 (Tab. 1). Albeit, amidst all these efforts, the river still remains polluted up to present.

Hydrology of Balili River

Originally, Balili River was a small creek, locally termed as 'pa-dok'. It was termed as Arroyo de Mapili during the Spanish Period and was not connected to the swampy area of the La Trinidad valley, thus not serving as natural drainage. But due to the flooding of the valley during the rainy season, Balili River was widened and opened up serving now as the drainage of the swampy area of La Trinidad. This was further improved during the American Period forming an irrigation system. Subsequent improvement of the drainage and backfilling of low lying areas in the area have totally eradicated the swampy area of the La Trinidad to its current state (see Fig. 1a and Fig. 2, Annexes).

Table no. 1 Major Activities Conducted to Rehabilitate the River

Date	Activity (Nature/ Description)	Agency Involved
1970	Chemical analysis confirms polluted state of Balili River (La Trinidad is being tagged as 'Toilet Bowl of Baguio City)	Bureau of Health Baguio City
1986	Construction and Completion of the Sewage Treatment Plant of Baguio City	Baguio LGU
1999 April	Balili River Summit to plan the rehabilitation of the Balili River	LGU, DENR and some academe
1999 June	Major clean-up activity	DENR-CAR, and line agencies, GU, NGO, academes in Baguio City and La Trinidad
2005 February	DPWH was asked by CEPMO to open manholes to trace illegal sewage systems	CEPMO, DPWH
2011 May	DPWH designated to clear constriction of waterways	
2010-2011	Formation of Balili River System Revitalization Coalition (BRSRC, Inc.) from different government agencies, LGU, academe, NGOs and Pos tasked to oversee the revitalization of Balili River	Several government agencies, LGU, academe, NGOs and Pos
2011 June	Baguio City Mayor Domogan declared his support to the implementation of the demolition of illegal structure along river easements	Baguio LGU
2011 July	Assessment and reporting on constriction	Baguio LGU
2011 Sept.	Designation of September 16 as Balili River Day	BRSRC
2011 – present	Post Ondoy and Pepeng Short-Term Infrastructure Rehabilitation Project to stabilize the river bank of Balili River	DPWH
2015 – present	Designation of Balili River as Water Quality Management Area	BRSRC

Source: BRSRC (2012)

At present, Balili River has a total length of 23.81 kilometers traversing the city of Baguio and the municipalities of La Trinidad and Sablan before entering the province of La Union. Its headwaters area is the Sagudin Creek, which flows along Barangay Trancoville, Baguio. The Sagudin Creek itself counts 23 tributary creeks stemming from the city's populated barangays, which include Santo Niño (also known as the Slaughterhouse Compound), New Lucban, Guisad, Honeymoon, Cabinet Hill, and Pacdal. From Baguio City the Balili River flows northward, entering the municipality of La Trinidad. It traverses the barangays of Balili, Cruz, Poblacion, and Bineng, where other tributaries drain into the river. From the western side of the valley Wangal, Puguis, Bayabas and Pico Creeks run across the valley converging as Bolo Creek, which then drains into Balili River at Poblacion. Draining from Busol Watershed in the eastern side of the valley are Ambiong, Tawang and Lubas Creeks, which join Balili River at Km 4. At upstream Bineng, there are several mini-hydroelectric power plants operated by the

Hydroelectric Development Corporation (HEDCOR). At downstream Bineng, the river merges with Tuel River and continues its flow westward until it reaches the municipality of Sablan. It supplies another HEDCOR-operated mini-hydroelectric power plant, the Ampohaw Hydro, along Barangay Banengbeng. It flows into Bagulin, La Union eventually draining into Naguilian River.

The pollution of Balili River was documented as early as 1960s (BSRSC 2012). Back then, the polluted condition of Balili River was already being flashed in local and national media making farmers lose market in US bases and Metro Manila for their vegetables. Mamoyac (1970) reported the first validated polluted condition of the river based on chemical analyses conducted by the Bureau of Health from Baguio City. However, this did not prevent the DENR-EMB from declaring the Upper Naguilian River System (which includes Balili River) as one of the Class A waters in 1975. Amidst these reports, it was only in 1990 that the first comprehensive study on the pollution state of the river was conducted by Abedania et al. Based on the biological (flora and faunal counts), physical (temperature, light transmittance, velocity and stream flow) and chemical parameters (pH, nitrate, total phosphorus, sulphate, dissolved oxygen - DO, biological oxygen demand - BOD), their study concluded that the river had already been polluted with organic matters particularly at stations near Baguio City. The water quality generally improves at stations away from Baguio City and during the rainy season.

After this study, no comprehensive study was conducted again in the river. There were few undergraduate theses, but were often concentrated on certain creek tributaries (Tab. 2). For example, Carbonel et al. (2003) documented the water quality of Gayasi Creek, a tributary coming from Barangay Wangal, and found it to be within the water quality standard for pH, DO, BOD, though not for coliform. Binwag et al. (2001) also discovered that Bolo Creek irrigating strawberry fields was contaminated with fecal coliform, but heavy metal concentration, such as lead and cadmium, were lower than the water quality standard (DENR-EMB 1990).

Table no. 2 Water Quality Results in Tributaries of Balili River

Water Quality Parameters	Balili River Tributaries		
	Gayasi Creek (Carbonel et al. 2003)		Bolo Creek (Binwag et al. 2001)
	Range	Mean	
TSS (mg/L)	28.5 – 35	32.5	-
pH	7	7	-
DO (mg/L)	4.70 – 5.39	5.12	-
BOD (mg/L)	1.67 – 2.00	1.89	-
Nitrate-nitrogen (mg/L)	0	0	-
Chloride (mg/L)	3.85 – 4.68	4.175	-
Total Coliform (MPN/ 100ml)	337.50 - ≥1,750	≥1,295.83*	≥16
Fecal Coliform (MPN/ 100ml)	329.75 - ≥1,800	≥1,172.42*	0 – 2.2
Cadmium (mg/L)	-	-	>0.01
Lead (mg/L)	-	-	>0.03

* higher than water quality standard (DAO 34 series of 1990)

Physical Parameters

The physico-chemical water quality of Balili River is presented in Figure 3 (Fig. 3a to 3g, Annexes). The water temperature has significantly warmed from 1990, compared to 2011-2016 data (Fig. 3a, Annexes). Temperature data range from 17-20 ºC in 1990, lower than the 18-25 ºC in 2011- 2016. This could be directly attributed to global warming, but could also be due to urban congestions affecting Stations 1 and 2. The water temperature is relatively higher during 1st and 2nd quarters, since these include summer months where temperatures are warmer. On the other hand, fluctuations between stations could be attributed to the time of sampling, since it is not synchronized. These temperature readings of Balili River are comparable with other river systems sampled in Benguet Province. Bestre et al. (2010) documented the water temperature of Agno, Amburayan, Amposongan, Galiano, Dopi Rivers and their tributaries ranging from 19-28 ºC.

On the other hand, total suspended solids (TSS) is statistically higher at Stations 1 and 2, particularly during summer months (see Fig. 3b, Annexes). This is expected, since these stations are near Baguio City and the congested human settlements. TSS settles as the river flows towards Stations 3 and 4, thus yielding lower results. Between the quarters of the year, the difference in TSS is directly attributed to rainfall. Quarters 1 and 2 usually have higher TSS, since these are the months when there is less rain to dilute the river. Quarter 2 usually has lower TSS than Quarter 1 due to the presence of diluting rains starting in May or even as early as mid-April.

Chemical Parameters

The pH readings of the four stations are generally within the 6.5 – 8.5 water criterion set in DAO-34 series of 1990 (Fig. 3c, Annexes). However, the 1990 data featured slightly acidic, while the 2011-2016 data were generally basic. The basic condition of the water could be attributed to the occurrence of calcium carbonate in the water. This compound is naturally occurring with rocks being weathered and absorbed by the flow of water. Statistically, the pH between stations is not significantly different.

Dissolved oxygen (DO) values in the 1990 data show a distinct pattern (Fig. 3d, Annexes). The stations near Baguio City, namely 1 and 2, record low DO and improve as the water flows downstream to Stations 3 and 4. DO also improves with the rainy season as more water dilutes and creates more flow in the river, as seen in Quarters (Q) 3-4. This trend is also observed in the averaged 2011-2016 data, but if observed throughout the year, the DO of the four stations fluctuates wildly with respect to the water standard (5mg/L). This indicates that there are several sources of DO-depleting pollutants (usually organic pollutants) from tributaries coming from La Trinidad. In 2012 and 2014, the majority of the stations are below the 5mg/L water criterion for DO. However, there was also suspect data revealing that some stations registered very high DO of 8 to 13 mg/L. That value is near the maximum amount of DO that water can hold at 14.7 mg/L in sea level and 0ºC. These DO values are not expected in polluted rivers like Balili River. These values are also comparable to the 7-8.5 mg/L DO registered in other relatively cleaner rivers of Benguet such as Agno, Amburayan, Amposongan, Galiano, Dopi Rivers and their tributaries (Bestre et al. 2010). Moreover, CEPMO data in 2013 registered much lower DO value of 2.41-2.71 mg/L in same stations.

On the other hand, BOD of the four stations consistently fails the water criterion (5mg/L) through the years (Fig. 3e, Annexes). A reversed trend with DO is witnessed, Stations 1 and 2 have higher BOD which lowers as the water flows downstream to Stations 3 and 4. BOD also improves with the rainy season as more water dilutes the pollutants in the river. This trend is still observed in 2011-2016, though less prominent, as there are little outlying data. Likewise, BOD in 2011-2016 data is statically higher that of the '90s across stations and quarters. This indicate presence of more organic pollutants in the river and/or more sources coming from La Trinidad valley as there are already rapid urbanization in different areas of the valley.

Nutrient load of the river, in terms of phosphate and ammonia, is also consistently higher than the water criterion (Fig. 3f and g, Annexes). Ammonia does not have water criteria in DAO-34, but 1 mg/L indicates organic matter pollution and a lethal concentration for fish of 2.5 mg/L (Bestre et al. 2010). The highest phosphate and ammonia concentrations were both recorded in Station 1, at 11.65 and 50.45 mg/L, respectively. These results showed that Balili River is loaded with high amount of organic matters that fishes cannot tolerate particularly during summer. These values are also much higher than those in other rivers of Benguet province. Bestre et al. (2010) recorded the phosphate and ammonia concentrations in Agno, Amburayan, Amposongan, Galiano, Dopi Rivers and their tributaries at 0-1.85 and 0-0.15 mg/L, respectively.

The same trend with BOD, phosphate concentration in 2011-2016 is higher than the ’90s data; higher in Stations 1 and 2 and lower downstream in Stations 3 and 4. It also lowers with the rainy season. There are several sources of phosphates and ammonia in Balili River. It would foremost be due to detergents and sewages from households and agricultural run-offs. Households near the river are observed directly dumping their laundry and dishwashing waters into the river.

Biological Parameters

Total coliform and fecal coliform in all stations have exceeded the standard throughout the sampled period, not just consistently but emphatically fairly much above the 1000 MPN/ 100 ml set for total coliform and 100 MPN/100 ml for fecal coliform (Fig. 4a and b, Annexes). Both coliform counts reached million and even billion values in all stations. These results further confirm that the river is not just loaded with organic matter but also with fecal matters. This can be easily verified by conducting an ocular inspection along the river. These fecal matters come from several sources such as from septic pipes directly connected to the river, animal feces from slaughter houses near the river or brought by run-off. There were also reports that the Baguio City Sewage Treatment Plant is operating beyond its maximum capacity, contributing to its inefficient treatment in removing coliform (Tabanda 1988). Those untreated coliforms go directly to the river. Coliform counts did not lower in downstream stations, nor during the rainy season (Aro 2011)

However, the million and even billion values of coliform count are hard to contextualize, particularly to non-microbiologists. While it is true that the river is indeed contaminated with fecal matters, those values may seem to exaggerate the actual condition of the river. One may think that the river is overflowing with fecal matters everyday at every point. According to Oasis Design, coliforms naturally multiply and that MPN values do not accurately reflect the actual fecal content in waters. Using the conversion developed in Oasis Design, the estimated amount of fecal matters in Balili River may range from 33 to 18,000 g/m^3 of water.

Heavy Metal Content

Heavy metal analysis of Balili River showed that it is contaminated with lead (Fig. 4c and d, Annexes). The lead concentration fluctuates among the four stations, but one or two stations, though not concurrent, consistently exceed the water criterion throughout the sampling period. There are several possible sources of lead in the river such as paints (of old buildings or discarded residues), several furniture and car shops, vehicular emissions that settle on the water or have been carried by run-off, and many others. On the other hand, the river’s mercury content is generally within the permissible level except in Stations 1 and 2 in 2014. However, the dumping of mercury-containing contaminants in the river might have been one-time as the succeeding sampling yielded negative results.

Ecology of Balili River

As a habitat, the biodiversity of Balili River changes with the change in its water quality (Tab. 3). The river previously hosted fishes commonly found in other rivers of Benguet such as 'bonog' (*Glossogobius circumspectus*), 'paideng' (*Pseudogobius javanicus*), yoyo (*Misgurnus anguillicaudatus*), igat (*Anguilla* sp.), moonfish, frogs and shells (BRSRC 2012). Introduced fish species were also documented such as *Micropterus salmoides* during the American time and gold fish (*Carassius auratus*) during Japanese time (Butler 2006). None of these are now observed in the river.

Table no. 3 Biodiversity of Balili River before and after its pollution

Organisms	Pre-Spanish to Japanese Time (Source: BRSRC 2012)	1946 to present (Sources: Abedania et al.1990; Napaldet and Buot 2016)
Plankton/Algae	-	(Cynophyta) *Chlorococcum* sp., *Gleocapsa* sp., *Oscillatoria* sp. (Chrysophyta) *Fragilaria* sp., *Gomphonema* sp., *Synedra* sp., *Navicula* sp., *Pinnularia* sp., *Nitzchia* sp., *Melosira* sp., *Schizomeris* sp. (Chlorophyta) *Chaetphora* sp., *Chlorella* sp., *Oedogonium* sp., *Scenedesmus* sp., *Spirogyra* sp., *Ulothrix* sp., *Cylindrocapsa* sp., *Stigeoclonium* sp.
Protozoans	-	*Arcella* sp., *Colpidium* sp., *Euglena* sp., *Eudorina* sp., *Didinium* sp., *Paramecium* sp., *Vorticella* sp., *Pandorina* sp., *Stylonichia* sp., *Euplotes* sp., *Amoeba* sp.
Aquatic Macrophytes	*Colocasia esculenta*, *Diplazium esculentum* and edible algae	Floating macrophytes: *Nasturtium officinale* and *Azolla* sp. Lower littoral plants: *Alternanthera sessilis*, *Amaranthus spinosus*, *Cucurbita maxima*, *Cynodon dactylon*, *Cyperus distans*, *Eleusine indica*, *Mikania cordata*, *Pennisetum purpureum*, *Polygonum barbatum* Upper littoral plants: *Alternanthera sessilis*, *Phyllanthus tenellus*, *Bidens pilosa*, *Commelina diffusa*, *Crassocephalum crepidioides*, *Cynodon dactylon*, *Desmodium procumbens*, *Ipomoea cairica*, *Lantana camara*, *Leucaena leucocephala*, *Mikania cordata*, *Paspalum conjugatum*, *Rumex obtusifolius*, *Tithonia diversifolia*
Macro Fauna	*Glossogobius circumspectus*, *Pseudogobius javanicus*, *Misgurnus anguillicaudatus*, *Anguilla* sp., moonfish, frogs and shells Introduced: *Micropterus salmoides*, *Carassius auratus*	mosquito fish (*Gambusia affinis*) reported: tilapia (*Oreochromis mossambicus*)

The earliest biodiversity inventory of the Balili River was conducted by Abedania et al. in 1990. They documented several floral and faunal (micro and macro) species in the river. Most dominant among the planktonic and algal species is *Spirogyra* sp. which is commonly associated with organically loaded waters. Aquatic macrophytes such as *Nasturtium officinale* and *Azolla* sp. were also documented. The macro-faunal species identified include several protozoans, mollusk (*Limnaea* sp.), aquatic worm (*Aelosoma* sp.), chironomid mosquito and rotifers (*Proales* and *Philodina* sp.).

In the most recent floral inventory conducted by Napaldet and Buot (2016), floating macrophytes such as *Nasturtium officinale* and *Azolla* sp. were not observed. Instead, common weeds such as *Alternanthera sessilis*, *Pennisetum purpureum*, *Eleusine indica*, *Cyperus distans*, and *Amaranthus spinosus* dominated the lower riparian area of Balili River. A total of 9 floral species were documented in the lower littoral zone, while 14 in the upper riparian zone. The index of similarity between upstream, midstream and downstream lower littoral zone is very high, though very low compared with upper riparian zone.

In terms of faunal diversity, no recent inventory has been conducted in the river but ocular observation would show thousands or even millions of mosquito fish (*Gambusia affinis*) blackening the river banks especially during summer months. Also, there were some reports that tilapia (*Oreochromis mossambicus*) was sometimes caught in the river but only during or immediately after the rainy season when the river is relatively diluted. Most likely, these are fish that have escaped from the BFAR fishponds at Tabangoen near Balili River.

Conclusions:

This study reviewed and summarized the history, hydrology and ecology of Balili River as part of the effort for its rehabilitation. Historically, Balili River is the cradle of civilization in La Trinidad or even in the entire province of Benguet. It started as small creek (‘pa-dok’), but was then widened as early as the Spanish period to become the main drainage of the previously swampy area of La Trinidad. The river previously host variety of indigenous fishes which serving as food. It is also a major source of irrigation and site of recreational activities up to Japanese time. But with the urbanization of La Trinidad and its headwater, Baguio City, this river became a sewer and is severely polluted. This was documented as early as 1960s, being flashed in local and national media. A 1990 study showed that the river was most polluted near Baguio City and the water quality improves as it flows downward. However, this trend is no longer observed in the 2011-2016 EMB-CAR monitoring data. This indicates that there are several sources of pollutants from La Trinidad itself as there is already rapid urbanization in different parts of the valley. The river recorded very high BOD, high nutrient load (phosphate and ammonia), very high total and fecal coliform, and lead contamination. Several efforts have been exerted to rehabilitate the river as early as 1970 to present, though it is still polluted. This could be partly attributed to the limited and lack of in-depth scientific studies on the river that could serve as important baseline information for the rehabilitation efforts. It was observed that data about the rivers are gray literature and are not easily accessible for the public. Amidst these challenges, there is still a need to continue the rehabilitation effort for the river as it still serves as a major source of irrigation and domestic water in the valley. Also, it is highly recommended that agencies monitoring the water quality of the river or conducting rehabilitation efforts should publish their result in scientific journals as to make their data readily accessible, for information, dissemination purposes and to improve their general performance from the comments and suggestions provided by experts.

Rezumat:

ISTORIA, HIDROLOGIA ȘI ECOLOGIA RÂULUI BALILI, LA TRINIDAD, PHILIPPINES

Acest studiu a contribuit la documentarea privind istoria, hidrologia și ecologia râului Balili, ca parte a eforturilor de reabilitare a acestuia. Din punct de vedere istoric, râul Balili reprezintă leagănul civilizației din La Trinidad, Benguet. Inițial avea mărimea unui pârâu mic, dar ulterior a fost lărgit devenind principalul sistem de colectare din vale. Apele râului au fost curate până în perioada de ocupație japoneză, dar odată cu urbanizarea orașelor La Trinidad și Baguio au devenit puternic poluate. Studii anterioare au relevat faptul că râul a fost cel mai poluat în apropierea orașului Baguio și s-a îmbunătățit în aval, dar această tendință nu a mai fost observată în datele recente, indicând mai multe surse de poluanți din La Trinidad. La nivelul râului au fost înregistrate un BOD foarte ridicat, acumulare de nutrienți, bacterii coliforme și plumb dincolo de nivelurile admise. Pe de altă parte, această stare de poluare a avut repercursiuni și asupra biodiversității, dominantă fiind poluarea organică – asocieri de alge, buruieni comune și gambuzia orientală (*Gambusia affinis*). Au fost depuse mai multe eforturi pentru reabilitarea râului, dar acesta este încă poluat. Acest lucru ar putea fi parțial atribuit limitării și lipsei de studii științifice aprofundate pe râu.

References:

ABEDANIA H.D., RAFANAN J.R., FERNANDO D.D., MADRID J.C., BALWEG M.G.A. (1990), *The Hydrobiology of Balili River*. A Terminal Report, University of the Philippines.

ARO S. (2011), *Balili River to be designated as Water Quality Management Area possible*, PIA Press Release, Philippine Information Agency. Retrieved 13 January 2015.

BALLARD L., AFABLE P.O. (2011), *Ibaloi*, Diteng, Inc. and Cordillera Studies Center, UP Baguio, Philippines.

BRSRC (Balili River System Revitalization Coalition) (2012), *A History of Balili River System*, A video presentation by University of the Philippines Baguio.

BARANGAY BALILI PHYSICAL AND SOCIO-ECONOMIC PROFILE (on line) (2014). https://www.latrinidad.gov.ph/profile/barangay-profiles/balili-profile/physical-socio-economic-profile-bal/

BESTRE E.C., LUMIQUIO A.M., NAPALDET J.T. (2010), *Study 1: Water Quality Assessment of Major River System in Benguet Province*. A terminal report presented during the 2010 BSU Annual In-House Review.

BINWAG J.B., CAMILO B.P., GALANO W.G., NGA-OTOY J.B., TALATA H.B. (2001), *Assessment of Heavy Metals and Microorganisms in Irrigation water used for Strawberry Production*, Unpublished Thesis Benguet State University, p. 51.

BUTLER R. (2006), List of freshwater fishes for Philippines. http://www.fish.mongabay.com. (accessed 21 September 2017).

CARBONEL A.E., DELMAS F.D., LINGGON D.D., LITAWEN L.T., OCDEN J.B. (2003), *Water Quality of Gayasi River Wangal, La Trinidad, Benguet*, Unpublished Thesis Benguet State University, p. 72.

CEPMO (City Environment and Parks Management Office) (2013), *Water Quality Monitoring along tributaries to Sagudin-Balili River*, Monitoring Report.

DENR-EMB (Department of Environment and Natural Resources-Environment Management Bureau) (1990), *DENR Administrative Order no. 34 Series of 1990: Revised Water Usage and Classification Water Quality Criteria*.

LA TRINIDAD SOCIO-ECONOMIC AND PHYSICAL PROFILE (2014), Prepared by the Research & Evaluation Section, Municipal Planning & Development Office, 2015.

MAMOYAC G.E. (1970), River Pollution in Benguet Probed, *Manila Times*, Nov. 13, p. 13.

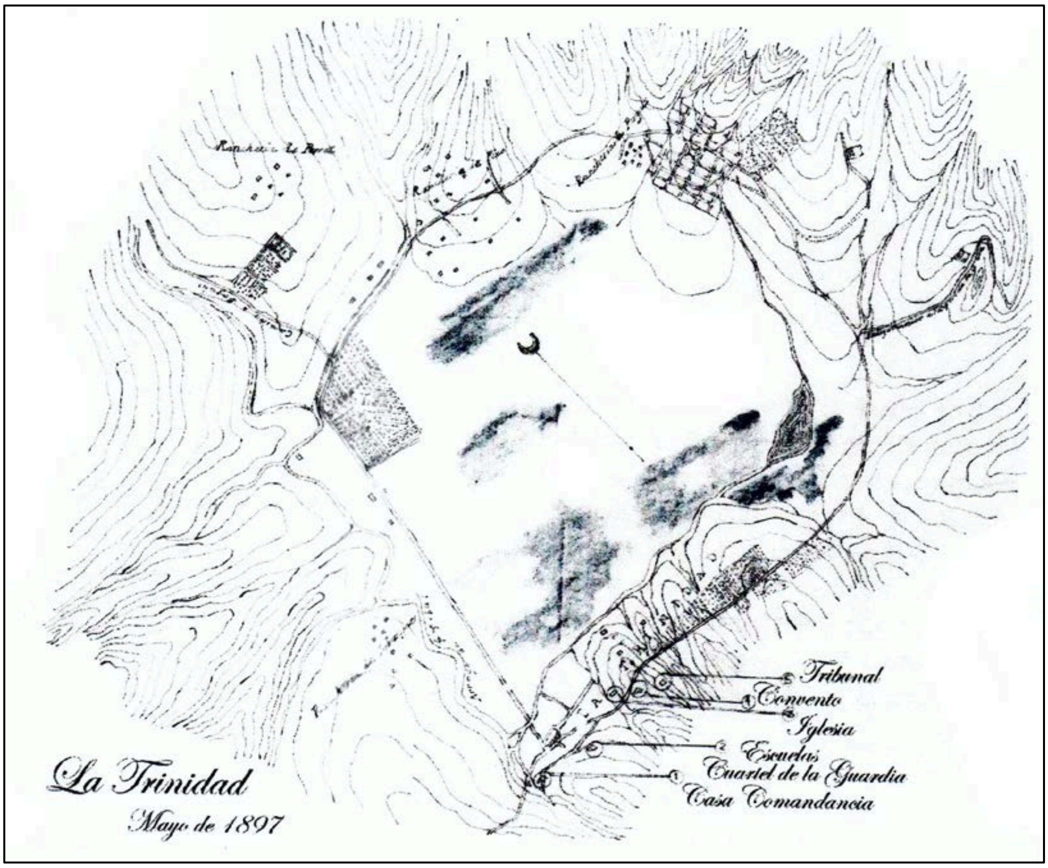
NAPALDET J.T., BUOT I.E. Jr. (2016), Floral diversity assessment of Balili River as potential phytoremediators, *Journal of Wetlands Biodiversity* 7: 17-28.

PALANGCHAO H. (2011), MOU inked in bid to save Balili River system, *Baguio Midland Courier* (accessed 13 January 2015).

TABANDA E. (1988), In: *Baguio Midland Courier*, "Tabanda chides city over Balili River pollution", XLI (24): 1 (June 12).

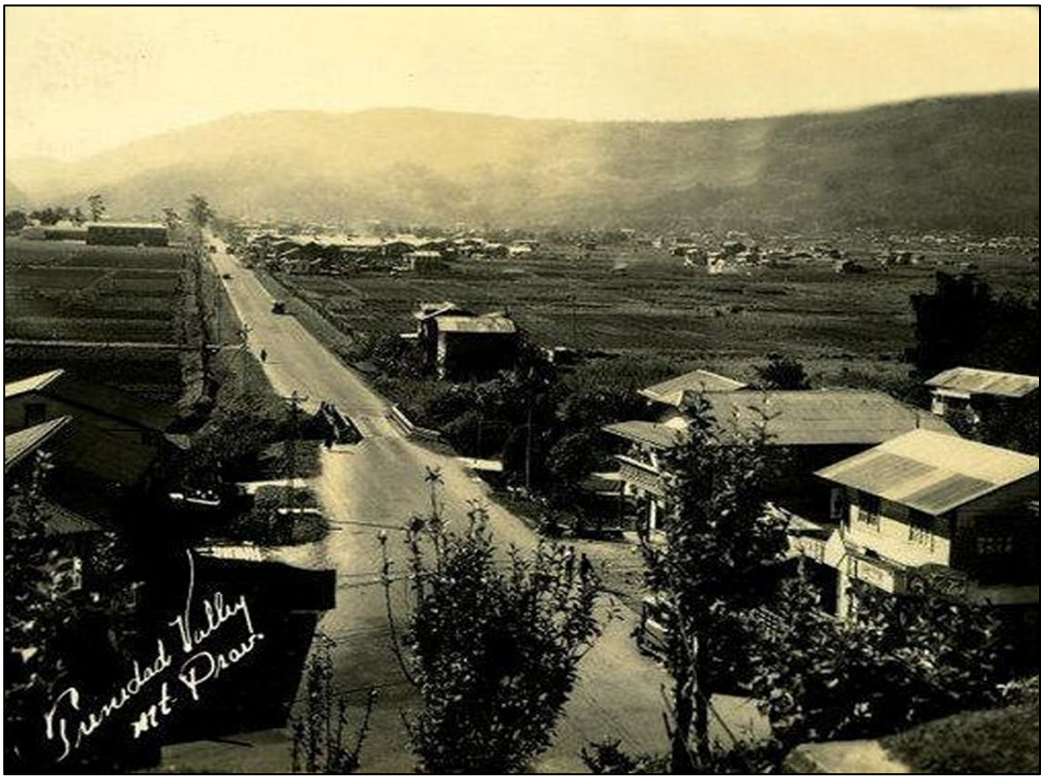
ANNEXES

Figure no. 1 Photographic history of Balili River (Pictures courtesy of BRSRC)
a - pre-Spanish to Spanish period (map adopted with enhancement from Ballard and Afable (2011)); b - American period; c - Japanese period; d and e - 1946 to present

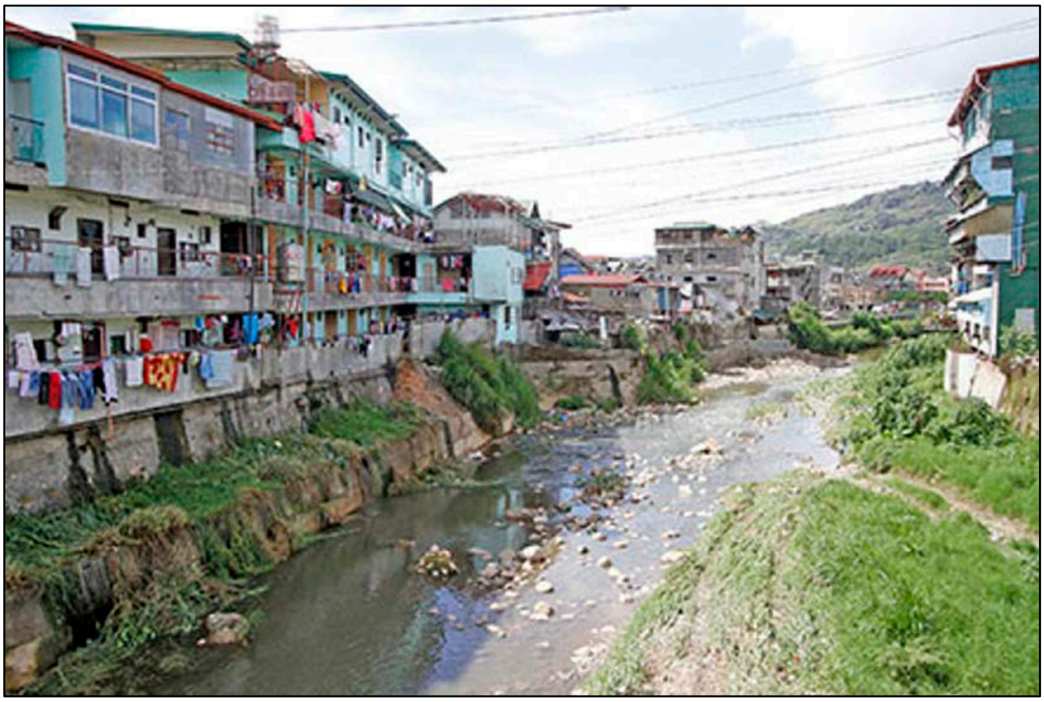


a

b

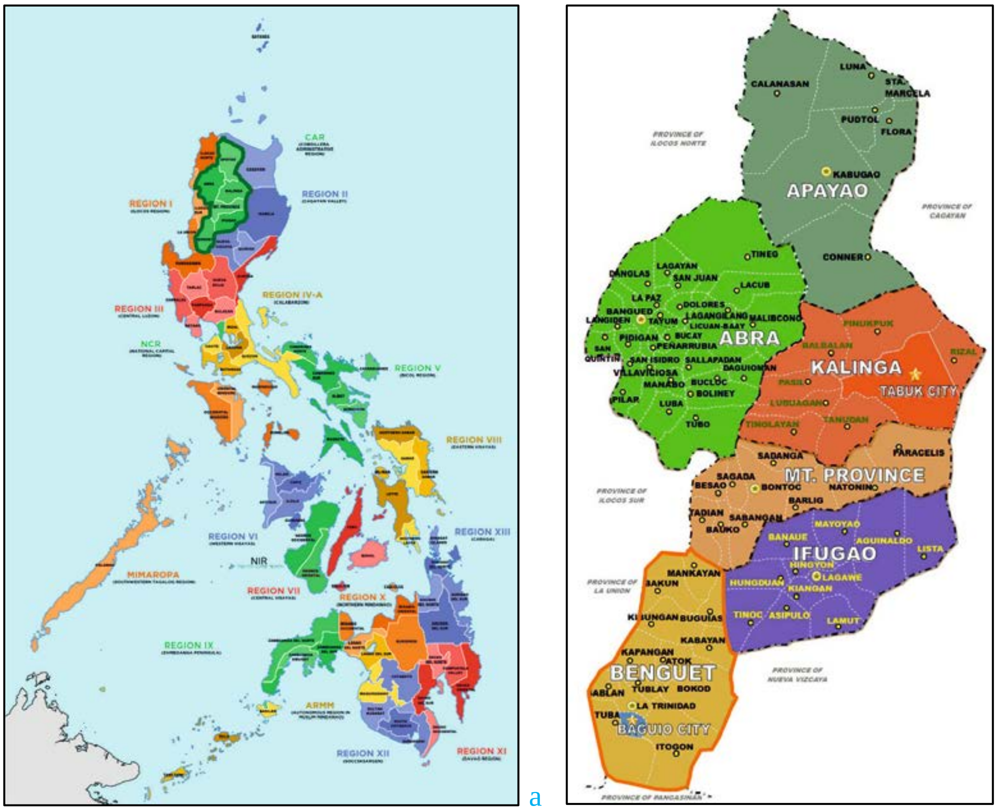


c

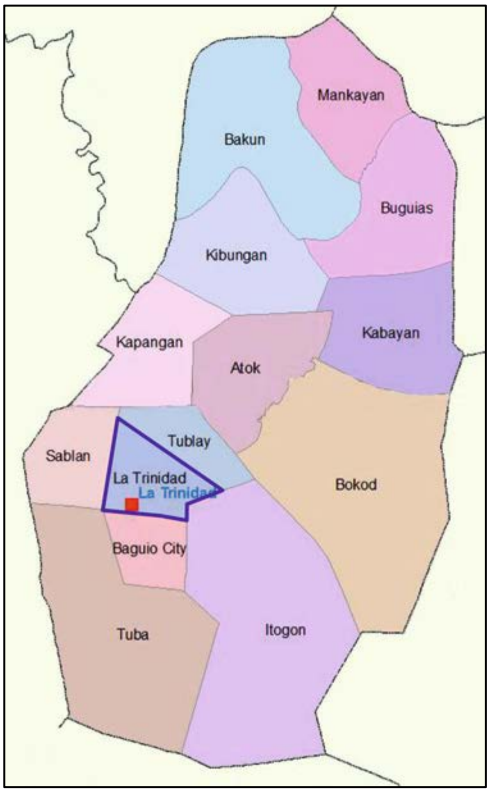

d


e

Figure no. 2 Current map of La Trinidad showing Balili River with the geographical location on the Philippine map
a - Philippine map with the Cordillera Administrative Region (green outline) (Data source: https://www.wikiwand.com/en/Cordillera_Administrative_Region); b - Cordillera Administrative Region with Banguet Province (orange outline) (Data source: http://www.pna-car.org/about-car/); c - Banguet Province with the La Trinidad Municipality (blue outline) (Data source: https://www.mapsofworld.com/philippines/provinces/benguet.html); d - hydrology of the La Trinidad Municipality (Data source: La Trinidad-MPDO.2018. Base maps. Barangay boundaries and river networks); e - the Balili River and its tributaries (blue outline) (Data source: La Trinidad, Philippnes, 16º28’38.74” and 120º35’07.68”, Google Earth. 15 April 2017. Accessed on 14 July 2018)

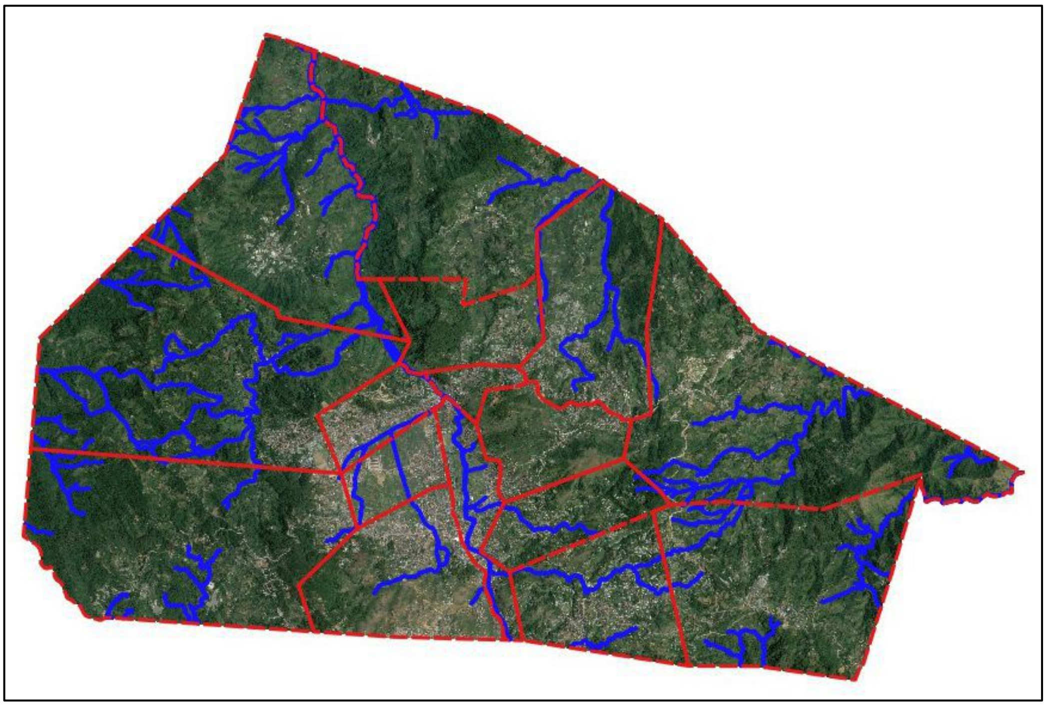


a b



Mankayan
Bakun
Buguias
Kibungan
Kabayan
Kapangan
Atok
Tublay
Sablan
La Trinidad
La Trinidad
Bokod
Baguio City
Tuba
Itogon

c


d

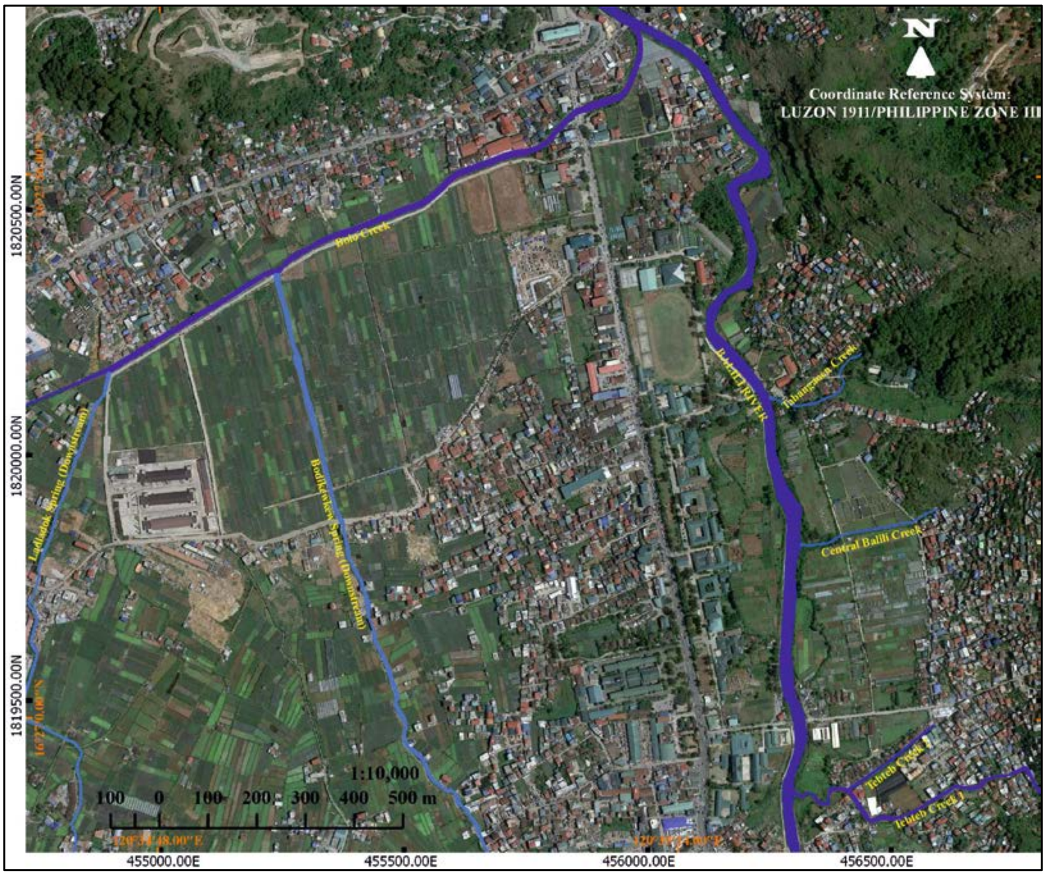
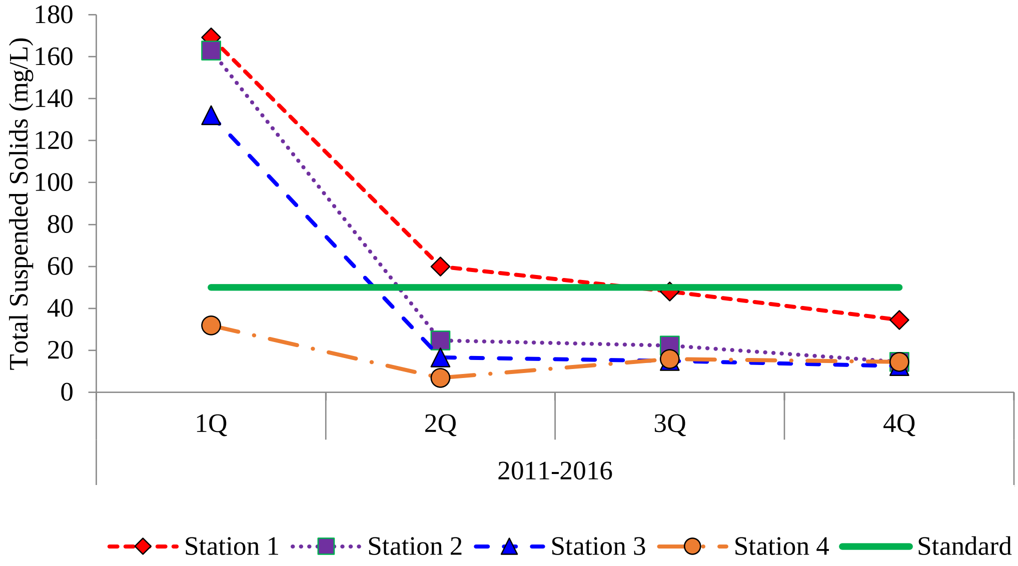
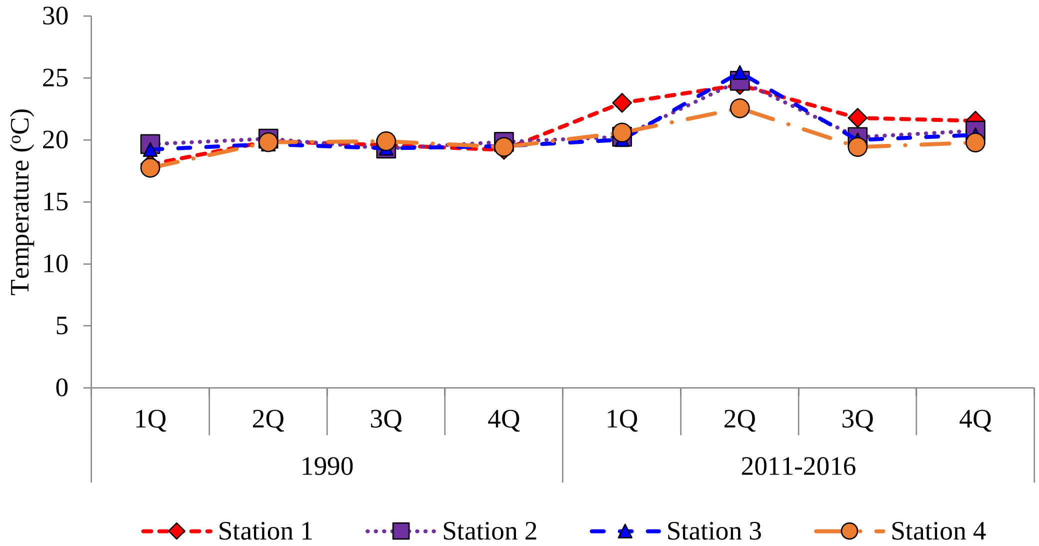

N
Coordinate Reference System:
LUZON 1911/PHILIPPINE ZONE III
Bolo Creek
Ladiadok Spring (Downstream)
Bodikewkew Spring (Downstream)
BALILI RIVER
Tabangaoen Creek
Central Balili Creek
Tebteb Creek
1:10,000
100 0 100 200 300 400 500 m
1820500.00N
1820000.00N
1819500.00N
455000.00E
455500.00E
456000.00E
456500.00E
e

Figure no. 3 Physico-chemical water quality of Balili River then and now

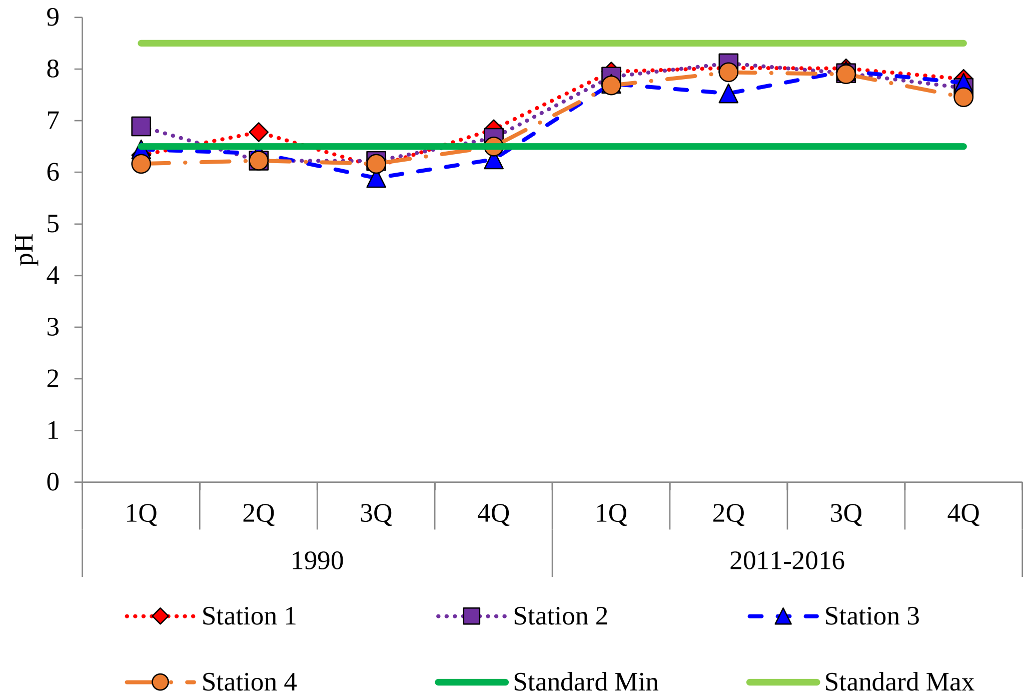
a.



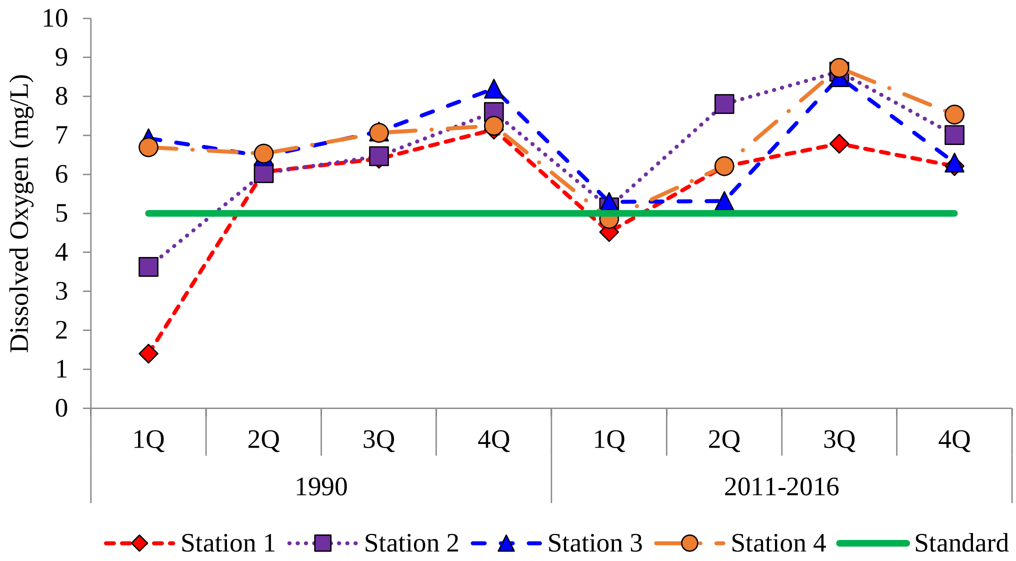
b.



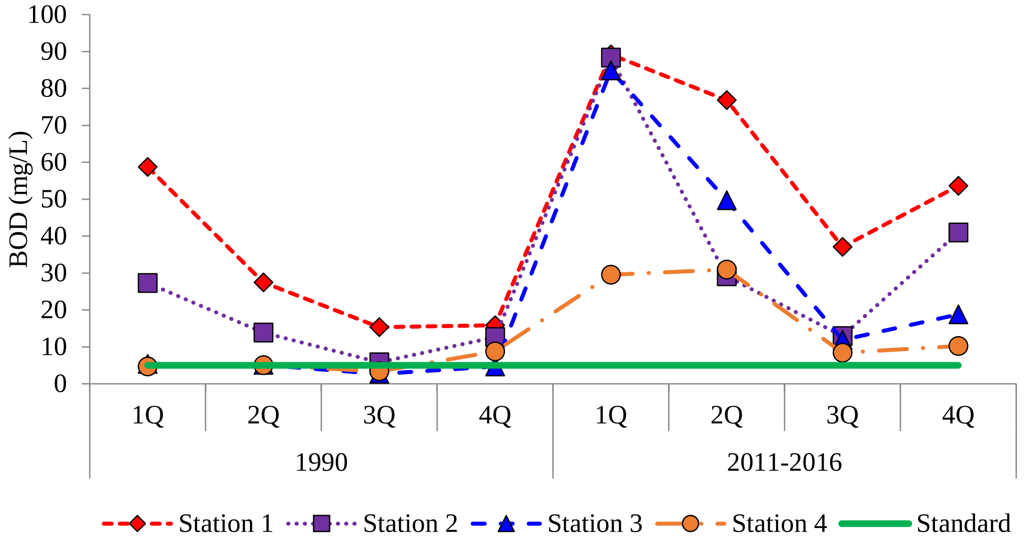
c.


9
8
7
6
5
4
3
2
1
0
pH
1Q
2Q
3Q
4Q
1Q
2Q
3Q
4Q
1990
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard Min
Standard Max

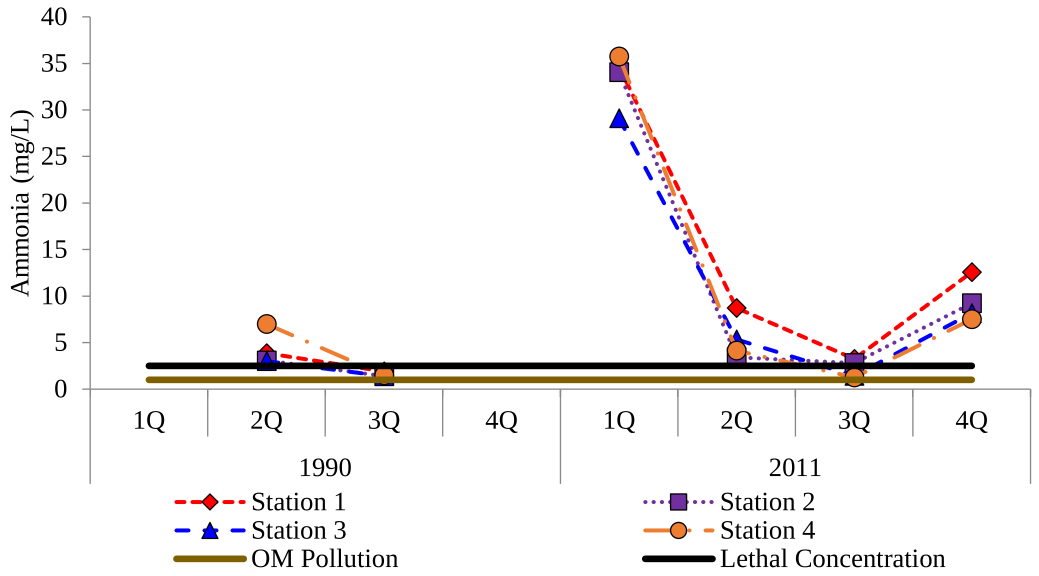
d.


10
9
8
7
6
5
4
3
2
1
0
Dissolved Oxygen (mg/L)
1Q
2Q
3Q
4Q
1Q
2Q
3Q
4Q
1990
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard

e.


BOD (mg/L)
100
90
80
70
60
50
40
30
20
10
0
1Q
2Q
3Q
4Q
1Q
2Q
3Q
4Q
1990
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard

f.


Ammonia (mg/L)
40
35
30
25
20
15
10
5
0
1Q
2Q
3Q
4Q
1Q
2Q
3Q
4Q
1990
2011
Station 1
Station 2
Station 3
Station 4
OM Pollution
Lethal Concentration

g.

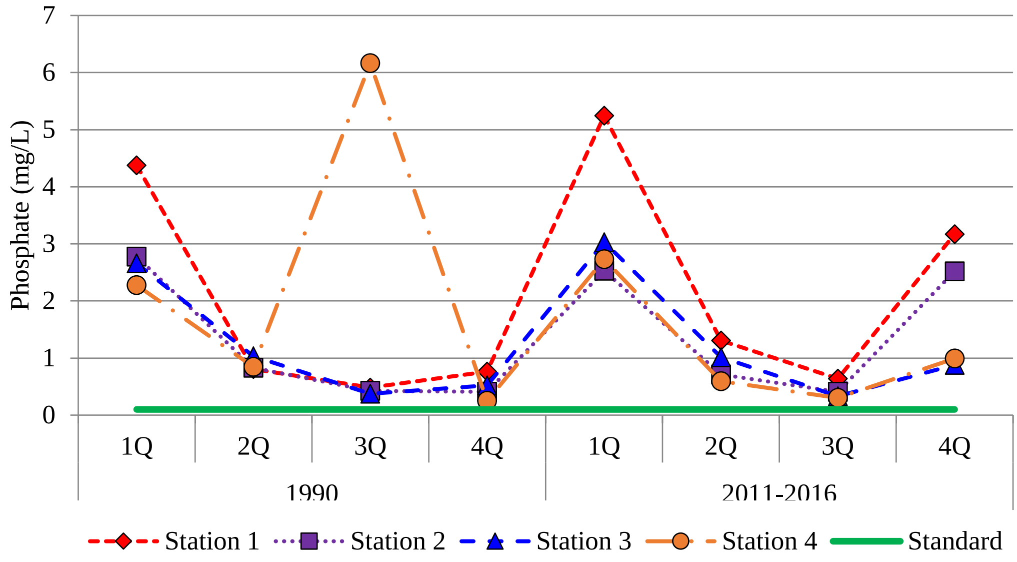
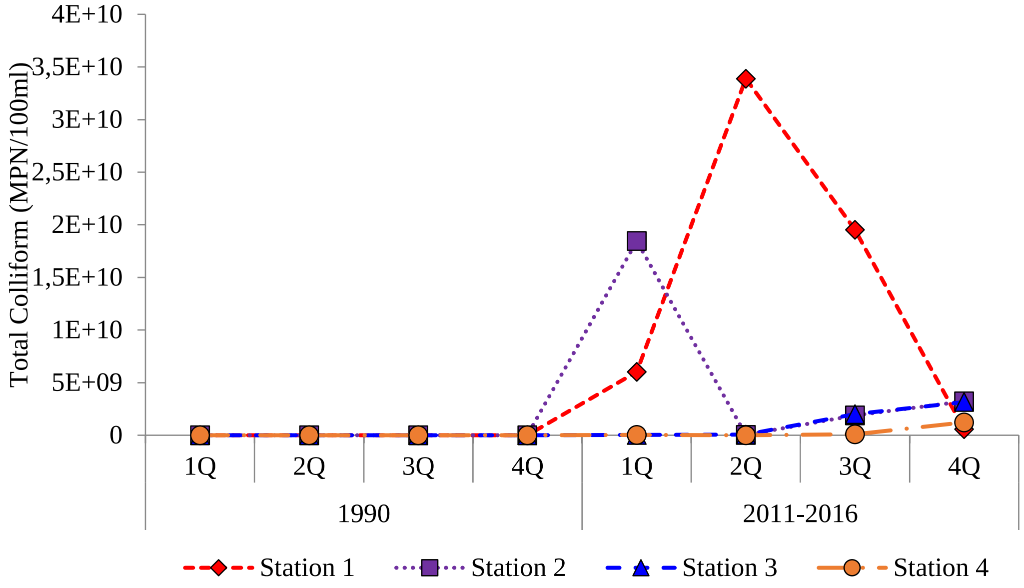
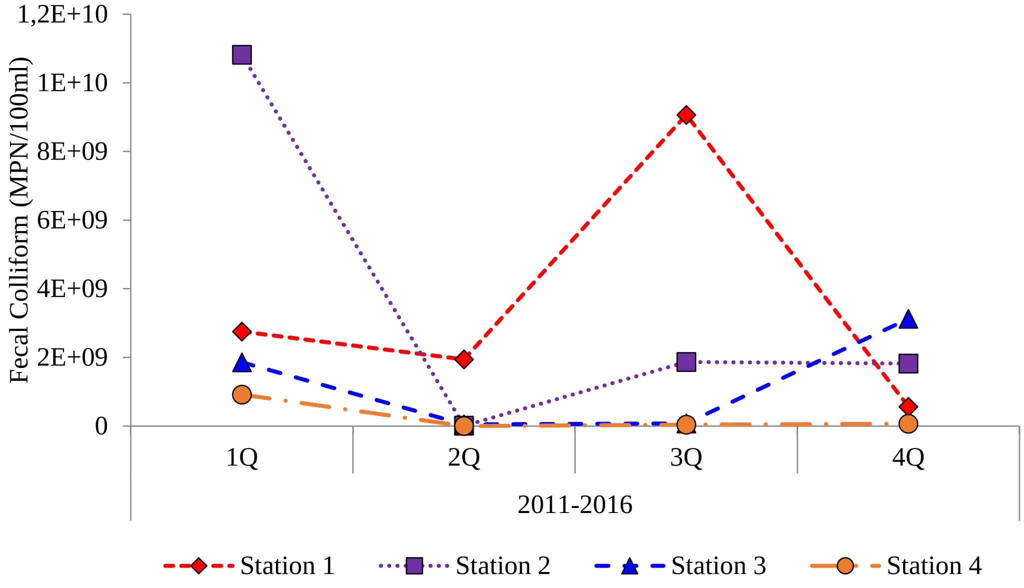

Phosphate (mg/L)
0
1
2
3
4
5
6
7
1Q
2Q
3Q
4Q
1Q
2Q
3Q
4Q
1990
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard

Figure no. 4 Colliform counts and heavy metal concentration of Balili River

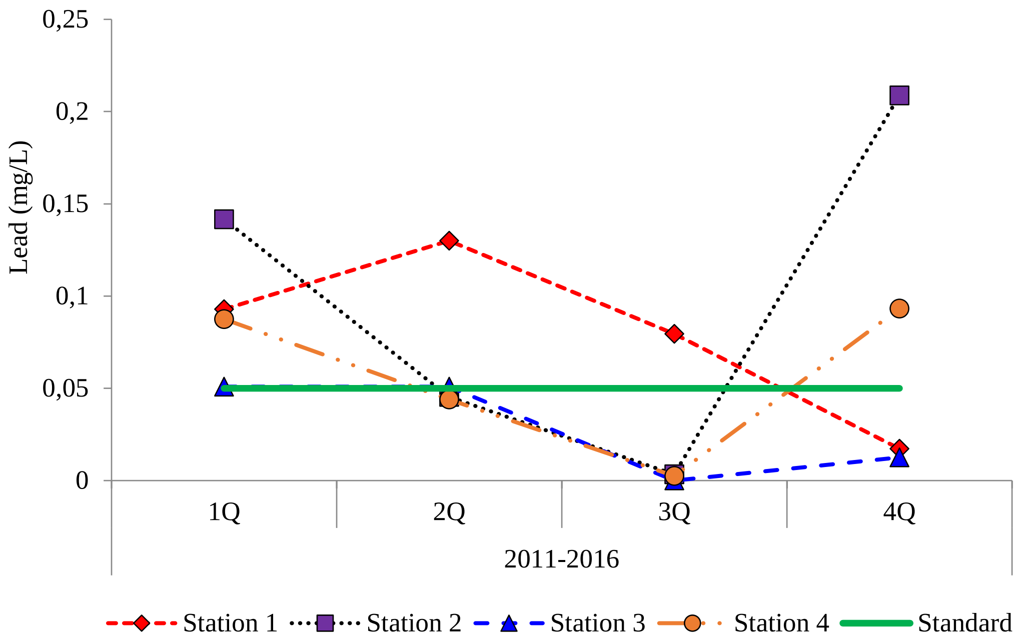
a.



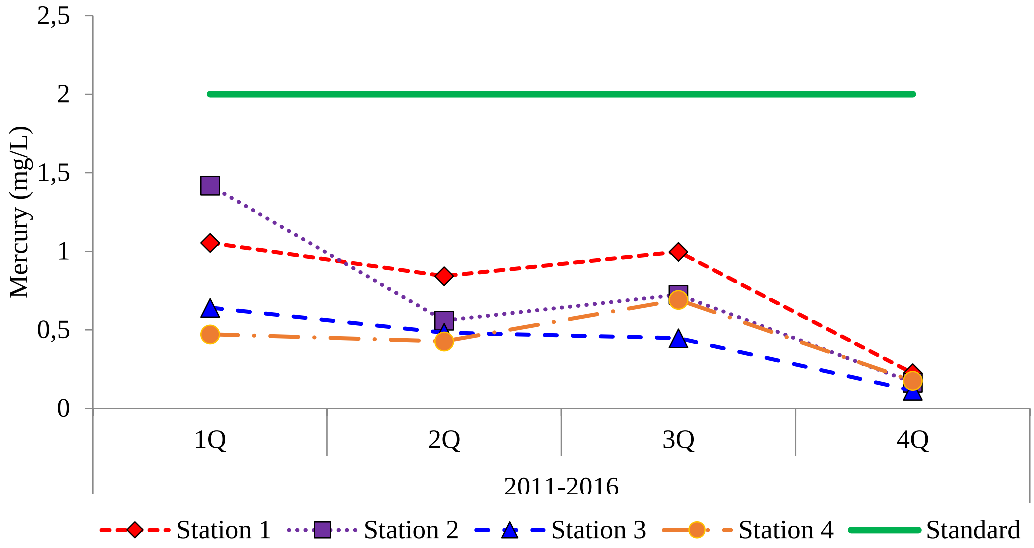
b.



c.


0,25
0,2
0,15
0,1
0,05
0
Lead (mg/L)
1Q
2Q
3Q
4Q
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard

d.


2,5
2
1,5
1
0,5
0
Mercury (mg/L)
1Q
2Q
3Q
4Q
2011-2016
Station 1
Station 2
Station 3
Station 4
Standard