The Role of Natural Ecosystem in Purifying Municipal Wastewater in Bahir Dar Metropolitan City

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Abstract. The main purpose of this study was to study the Ecosystem functionality in purifying municipal wastewater. Three drainage lines were selected to determine the efficiency of ecosystem in purifying waste water. The water quality parameters considered for this study were dissolved oxygen, total dissolved solids, biological oxygen demand, pH, conductivity, nitrate, phosphate, and ammonia. Pollutant load concentration flowing along to the three drainage lines and contributions to the Blue Nile river pollution were determined for the months March to May 2018. The load of BOD, TDS, and electrical conductivity, pH, nitrate, phosphate, and ammonia were reduced by 58.10%, 54.33%, 53.50%, 13.55%, 52.28%, and 75.20% respectively. The average concentration load of dissolved oxygen for canals #1 and #2 were enhanced by 70% while for Blue Nile river course it is reduced by 18%. Although the natural ecosystem show significant amount of reduction in chemical pollutants, the concentration in some parameters were still above the standard which requires enhancement of the ecosystem. Most water quality parameters of effluents at the Blue Nile river (Downstream) except BOD and DO were with within levels set by international standards for effluents to be discharged to surface water and FAO maximum permissible level set for waste water to be used for irrigation purposes. To reverse the adverse outcomes of effluents, treating wastes and preservation of the ecosystem is beneficial.

Keywords: Ecosystem · Wetland · Wastewater

1 Introduction

1.1 Background

Liquid waste discharge over water bodies is a daily practice in many developing countries [1, 2]. It is reported that 70% of industries in developing countries disposed their untreated waste in to water bodies and to the environment [3]. In Ethiopia, almost all natural waters are affected by municipal, agricultural, and industrial waste in the form of solids, liquids and hazardous materials [1]. The natural streams and rivers passing through cities such as Bahir Dar and Addis Ababa can be described as sewer

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lines for domestic and industrial waste [4]. Wastewater disposal is a serious problem in Bahir Dar City. Major institutions and industries like Bahir Dar University, Textile and tannery factories, commercial centers, and hotels discharge their effluents directly or indirectly into the natural streams and the municipal drainage system, and finally drained into Blue Nile river and Lake Tana without treatment (personal observation). It is estimated that two-thirds of the community living in Bahir Dar City discharge their domestic waste water in to streets and flood water drainages which ultimately end up to Blue Nile river.

Chemical and physical assessment is widely utilized to evaluate the efficiency of ecosystem in reducing pollutions of water bodies from different point and non-point sources. However, the combination of biological assessment with physio-chemical assessment is the most appropriate means of figure out the role of ecosystem to reduce pollution in aquatic system [1]. Because it can detect cumulative physical, chemical and biological impacts of adverse effect to an aquatic systems [5–7]. In Ethiopia, physio-chemical and biological parameters have been used as stream and river water quality indicators [1]; [8–11]. However information about the role and extent of ecosystem (sediment, macrophytes, planktons, and microbes) in purifying municipal wastewater is limited. Therefore, the objective of this study was to investigate the role of ecosystem to purify municipal wastewater in Bahir Dar City by using water quality parameter as indicators through the following research questions: (1) To what extent the natural ecosystem (vegetation, wetlands and big rivers) purify municipal wastewater in the longitudinal gradient of pollution? (2) To what extent the measured water quality parameters vary as compared to accepted international standard, and (3) How the Blue Nile river affected by the wastewater effluent?

2 Materials and Methods

2.1 Study Areas

Bahir Dar, the capital of Amhara National Regional State is situated on the Southern shore of Lake Tana, the source of the Blue Nile river, around 565 km, Northwest of Addis Ababa. The total population of the Bahir Dar was 220,000 in 2007, and has a population growth rate of 6.6% per year [12], which is more than twice as high as the average population growth rate in Ethiopia [1]. In Bahir Dar City, there are more than five constructed municipal storm water canals and few natural streams and water courses (e.g. Chimbil, Amora Gedel). The constructed drainage lines usually drain towards Southeast while the natural streams drain towards Southwest of the city. The areas studied in this manuscript are: (i) From Gudo Bahir reservoir along the Stadium to Peda, then to Blue Nile river including site numbers 1–7, 13 and 14 (hereinafter named canal #1); (ii) From Gudo Bahir reservoir along the Stadium to Yitamot wetland including site numbers 1–5, 8 and 14 (hereinafter named canal #2). (iii) The main Blue Nile river course from lake Tana to the end of the sampling station including site numbers 9–14 (hereinafter named Blue Nile river course).

2.2 Sampling

A total of 14 sampling sites were selected for testing the difference among the study areas mentioned above. Samples were collected three times between February and May 2018. Three replicates per site and per sampling time were applied. A total of 126 samples were analyzed. (Table 1 and Fig. 1).

Table 1. Description of sampling sites

Site	Description of location
1 (Gudo Bahir)	A reservoir to collect storm water from rural upstream and receive liquid and solid wastes from the surrounding industrial and residential areas. It is surface water in mudflats without buffer zone. It serves as grazing land, illegal garbage disposal. Nearby land is used for grazing and the community used to dump solid and mining of peat soil by the local communities
2 (*Kebele* 16 at the back of telecommunication.)	A natural municipal storm water drainage line/canal/buffered by swampy papyrus vegetation. The buffer is almost 50 m wide covered with 60% papyrus, 30% polygonium and 10% grass species. The storm water move very slowly
3 (*Kebele* 16 near Negde Weyto community)	Natural canal with relatively faster moving storm water. Although filled by garbage the bed is rocky with some grassy buffers. Since the *Negede* community had no sufficient sanitation facilities, they also use the canal as open field toilet
4 (*Kebele* 16 at the back of Fasillo School)	A natural canal with a larger volume since a mix with *kebele 3* drainage line, moderate movement and width, and mud bottom. It contains 70% polygonium and 30% of indigenous grass buffered by eucalyptus plantation
5 (*Kebele* 14 at the back of New Stadium)	A natural canal with large volume, very slow movement /since very gentle slope/ and higher width, and mud bottom. It contains 95% Polygonium and 5% of indigenous grass buffered by eucalyptus plantation
6 (*Kebele* 17 near Livestock market)	A natural canal with increasing volume since a mix with another bigger drainage line from papyrus hotel, though vertical but slow moving and higher width, and mud bottom. It was covered by 75% grasses, 20% polygonium, and 5% papyrus and partly buffered by eucalyptus plantation.. It serves was waste dumping, traditional tanning, and illegal slaughtering sites

(*continued*)

Table 1. (*continued*)

Site	Description of location
7 (*Kebele* 7 near Peda campus)	A natural canal with mud bottom and buffered by papyrus, and similar canal width to site 6. It was covered by 70% papyrus, 25% polygonium and 5% indigenous grass; then it receives wastewater from the Bahir Dar University and discharges its waste directly to the Blue Nile river
8 (Yitamot wetland)	A wetland open space that receives municipal wastewater from dividing line of site 5 along Silassie church, lower reach of *kebele 14* areas, and partly from peda campus. It is highly encroached by grazing, pollution and illegal settlement as well as open-field slaughtering
9 (Lake Tana in front of Bahir Dar Institute of Technology)	Lake Tana shoreline in front of Bahir Dar Institute of Technology campus. It is rich in papyrus and *Echinochloa sp* (Shafri/Shenkotet)
10 (Blue Nile river at Chere-chera)	A place where the river immediately outflow from the lake before the main Blue Nile river bridge. It was covered by 10% of indigenous grass, 80% *Echinochloa sp.* and 10% papyrus
11 (after Blue Nile bridge)	A place along Blue Nile river after the main Bridge. Car washing is a common practice. It was covered by 20% of indigenous grass, 80% *Echinochloa sp*
12 (After textile factory)	A place along Blue Nile river after the discharge of textile factory. It was covered by 20% of indigenous grass, 80% *Echinochloa sp.*
13 (Blue Nile river at *Teklehymanot* church traditional bridge)	Part of a river after the discharge of site 7 with mud bottom, relatively fast moving, and wider width. It was covered by 75% of papyrus and 20% polygonium 5% indigenous grass
14 (Blue Nile river downstream)	Blue Nile river, downstream of the study area that receives municipal wastewater from Ytemote discharge and from the *Teklehymanot* church wooden bridge. It is highly covered by *Echinochloa sp.*, papyrus and water hyacinth.

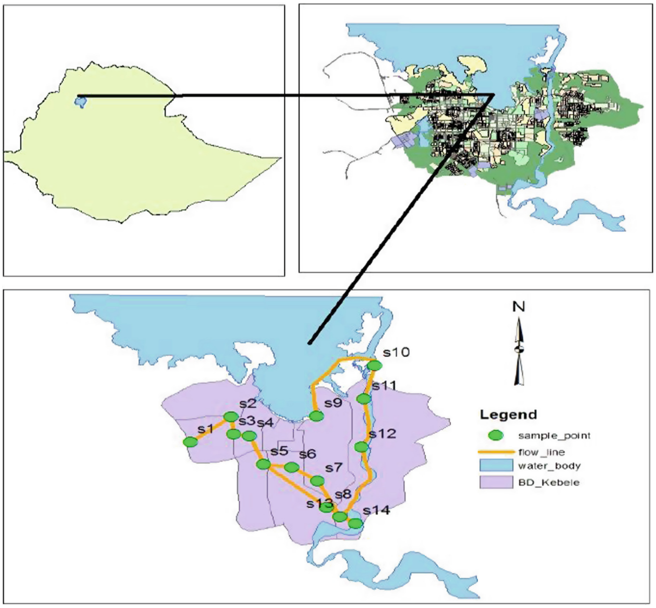

Fig. 1. Sampling sites location along the Bahir Dar municipal wastewater canal and Blue Nile river course.

2.3 Physiochemical Parameters

DO, pH, TDS, and conductivity were measured insitu using YSI 556 MPS Multi-probe field meter and samples for BOD_5 were analyzed according to standard methods (APHA 1998) and ammonia, nitrate, phosphate were analyzed using paqua lab 700 photometer. Water samples for laboratory analysis were collected and stored at 4 °C in polyethylene bottles that had been pre-washed with 10% nitric acid and thoroughly rinsed with de-ionized water [13].

3 Results and Discussion

3.1 Biological Oxygen Demand and Dissolved Oxygen for Canal #1

Table 2 presents values of water quality parameters for Bahir Dar municipal waste water drainage for Canal #1. For comparison purposes, food and agricultural organization (FAO) for irrigation as well as with world Health organization (WHO) maximum limits are included.

In Table 2 and Fig. 2 (**canal #1**); the minimum and maximum average value of BOD (range from 15.7–47 mg/L) and DO (range from 1.75–5.9 mg/L) were recorded at site 14 and 7 respectively. The p-values for BOD and DO parameters show significant variation ($p < 0.05$) in both cases. Even though the minimum BOD record exceeds the maximum allowable limits set by FAO for irrigation as well as with WHO for drinking, there is a significant difference in BOD among sites.

Table 2. Mean ± SE of water quality parameters for Canal sites. #1

Parameters	Site #1	Site #2	Site #3	Site #4	Site #5	Site #6	Site #7	Site #13	Site #14	p-value	FAO*	WHO*
BOD mg/L	36.5 ± 0.5	28.5 ± 0.35	44.99 ± 2	40.1 ± 0.8	34 ± 0.7	43.7 ± 1	47 ± 0.5	20 ± 0.35	15.7 ± .3	$p < 0.05$	10	<10
DO mg/L	3.32 ± 0.16	4.83 ± 0.1	1.78 ± 0.4	2.17 ± 0.4	3.2 ± 0.1	1.8111	1.75 ± .1	5.1 ± 0.1	5.9 ± .21	$p < 0.05$	2	>10
IDS mg/L	288.6 ± 3	445 ± 0.1	634 ± 2	529 ± 2.5	556 ± 2	653.5 ± 2	673 ± 2	171 ± 2.6	166 ± 1.5	$p < 0.05$	1000	300
Conductivity' µs/cm	398.5 ± 2.2	587 ± 1.2	870 ± 1.5	723 ± 1.5	733 ± 3	926 ± 2.7	967 ± 4.6	237 ± 2.5	245 ± 4.4	$p < 0.05$	350	250
pH	8.45 ± 0.03	8.95 ± 0.1	8.33 ± 0.1	8.23 ± 0.5	8.2 ± .04	8.2 ± 0.1	8.35 ± .6	7.7 ± 0.1	7.48 ± .07	$p < 0.05$	6.5–8.8	6.5–9.3
NO_3 mg/L	16.2 ± 0.3	14.84 ± 0.2	15.7 ± 0.1	17.8 ± 0.3	10.4 ± 0.2	4.8 ± 0.1	7.9 ± 0.1	6.69 ± .1	6.68 ± .1	$p < 0.05$		
PO_4mg/L	0.5 ± 0.1	7.7 ± 0.02	3.53 ± 0.05	3.9 ± 0.03	2.5 ± .03	2.6 ± 0.05	5.1 ± 0.2	0.46 ± .1	0.35 ± 01	$p < 0.05$	3	
NH_3 mg/L	3.45 ± .1	4.4 ± 0.03	5.8 ± 0.04	4.1 ± 0.03	3.1 ± .06	4 ± .08	5.45 ± .3	.59 ± 0.01	0.44 ± 0.2	$p < 0.05$		

*: FAO and WHO maximum accepted limits

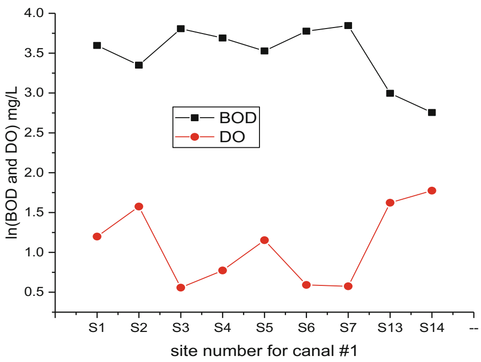

Fig. 2. BOD and DO values for Canal #1.

The maximum value of BOD and drastic reduction of DO at site 7 is mainly by receiving high concentration of organic waste that is biodegradable chemical organic waste from residential and commercial centers along the main canal (including *kebele* 03, 04, 07, 12, 15, and 16) and cultural leather processors and illegal slaughtering activities. Moreover, some residential houses and hotels directly connect their sewage to the municipal drainage lines. Most portion of the canal before site 7 is concrete paved and no option to uptake the waste by aquatic and wetland macrophytes. The drastic BOD reduction and improvement of dissolved oxygen at site 14 is explained by reduction in organic matter through nature based processes (sediment, vegetation, water volume) and ecosystem purification along the drainage canals and dilution effect of the Blue Nile river. A previous study conducted [14] in rainy season also confirms low dissolved oxygen with mean value of 2.4 mg/L in natural waste water canal that discharge to Blue Nile river from Bahir Dar city.

3.2 Total Dissolved Solids and Conductivity Nutrient and PH for Canal #1

In Table 2 and Fig. 3A, the minimum and maximum average values of TDS (range from 166-673 mg/L) and electrical conductivity (range from 237–967 µs/cm) were recorded at site 14 and 7 respectively. The p-value for both parameters show significant variation among the sampling sites ($p < 0.05$) for all cases. The maximum values for both parameters were recorded in site 6 and 7 where higher concentration and volume due to the collected effluents of wastewater from hotels, residents especially from garages.

As previously reported study[1] showed the mean value of TDS during the rain seasons was 738 mg/L. Because of increment of nutrient in rainy season the result is a bit higher than to the result of the current study.

A

B

C

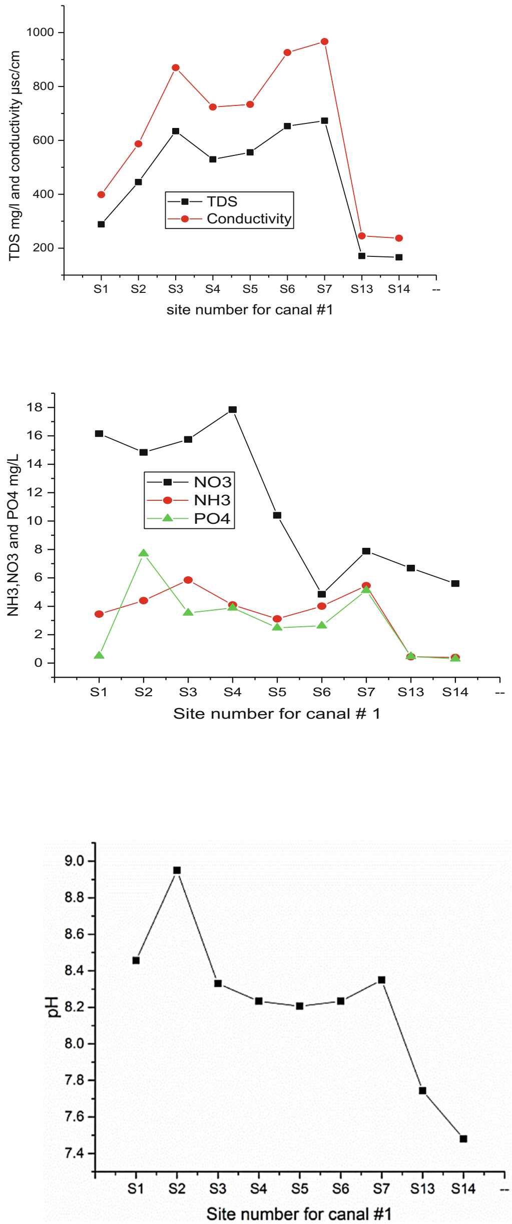

Fig. 3. TDS, conductivity, nutrients and pH variations for different sites of Canal #1.

From Table 2 and Fig. 3B, ammonia, nitrate and phosphate concentration ranges were from 0.44–5.8 mg/L, 4.85–17.8 mg/L, and 0.35–7.7 mg/L, respectively. Recorded nutrients were higher in three sampling sites (3, 4 and 2). This is because of direct effluent mix from various sources such as residential domestic wastewater including organic foods. As it moves from the upstream to downstream along the canal shows a trend of reduction due to many factors such as sediment adsorption, redox chemical reaction, microbial activities, vegetation absorption, macro-invertebrate consumption and dilution.

As shown in Fig. 3C, the mean value of pH ranges from 7.48–8.95 where record at site 14 and 2. The pH values were below the maximum allowable limit set by FAO as well as WHO . The mean value was significantly different among the sampling sites ($p < 0.05$) in all cases. High pH was recorded at site number two. The rising of pH at this site may be attributed the discharge of detergent waste water from *Keble* 16 condominium and from residence near by the drainage line might be contribute for rising of pH.

3.3 Biological Oxygen Demand and Dissolved Oxygen for Canal #2

Table 3 presents values of water quality parameters for Bahir Dar municipal waste water drainage for Canal #2. FAO and WHO maximum limits may be referred from Table 2.

In Table 3 and Fig. 4 (**Canal #2**); the average maximum and minimum concentration of BOD 45-15.7 mg/L and minimum and maximum concentration of DO 1.78–5.9 mg/L were recorded in site 3 and 14, respectively. The p-value for both parameters show significant difference ($p < 0.05$) in both cases. The observed reduction can be explained by biomass uptake and sediment adsorption.

Even though the maximum DO record were below the minimum allowable limit by WHO, and the minimum BOD record exceeds the maximum allowable limits set by FAO for irrigation as well as with WHO for drinking, there is a significant difference in BOD among sites. The maximum value of BOD and the drastic decreased of dissolved oxygen at site 3 is mainly by receiving high concentration of organic waste from residential (*kebele* 14 and 16) and commercial centers, open toilet of *Negedewch* community along the canal two.

Table 3. Mean ± SE of water quality parameters for Canal #2 sites.

Parameters	sitel	site2	site3	site4	site5	site8	site 14	P value
BOD mg/L	36.5 ± 0.52	28.5 ± .35	44.99 ± 1.5	40.1 ± 0.8	34 ± 0.67	26.6 ± 0.6	20 ± 0.35	$p < 0.05$
DO mg/L	3.32 ± 0.16	4.83 ± 0.1	1.78 ± 0.04	2.17 ± 0.04	3.2 ± 0.1	4.10.1	5.9 ± 0.21	$P < 0.05$
TDS mg/L	288.6 ± 3	445 ± .1	634 ± 2	529 ± 2.5	556 ± 2	977.5 ± 5	166 ± 1.5	$P < 0.05$
Conductivity' µs/cm	398.5 ± 2.2	587 ± 1.2	870 ± 1.5	723 ± 1.5	733 ± 3	929 ± 2.7	245 ± 4.4	$P < 0.05$
PH	8.45 ± 0.03	8.95 ± 0.1	8.33 ± 0.1	8.23 ± 0. 5	8.2 ± .04	8.2 ± 0.04	7.48 ± .07	$P < 0.05$
NO_3 mg/L	16.2 ± 0.3	14.84 ± 0.2	15.7 ± 0.1	17.8 ± 0.3	10.4 ± .2	2.76 ± 0.1	5.59 ± .1	$P < 0.05$
PO_4 mg/L	0.5 ± 0.1	7.7 ± 0.02	3.53 ± 0.05	3.9 ± 0.03	2.5 ± .03	0.43 ± 0.2	0.46 ± 01	$P < 0.05$
NH_3 mg/L	3.44 ± .1	4.4 ± 0.03	5.8 ± 0.04	4.1 ± 0.03	3.1 ± .06	3.8 ± .02	0.59 ± 0.2	$P < 0.05$

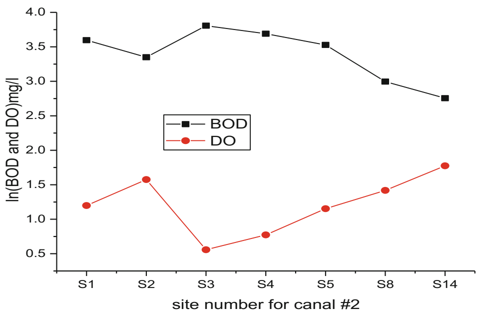

Fig. 4. Absolute value of BOD and DO versus site number for Canal #2

3.4 TDS, Conductivity, Nutrients and PH Variations for Canal #2

In Table 3 and Fig. 5A, the minimum and maximum average values of TDS (range from 166–977 mg/L) and electrical conductivity (range from 245–929 µs/cm) were recorded at site 14 and 8 respectively. The p-value for both parameters show significant variation among the sampling sites ($p < 0.05$) for all cases. The maximum values for both parameters were recorded in site 8. Where this site is a wetland open space that receive municipal wastewater from dividing line of site five along Silassie church, lower reach of *kebele* 14 areas, and partly from peda campus. It is highly encroached by grazing, pollution and informal settlement and open-field slaughter activities, automotive garage, and industrial chemicals.

Ammonia, nitrate and phosphate concentrations range from 0.59–5.8 mg/L, 2.76–17.8 mg/L, and 0.43–7.7 mg/L, respectively (Fig. 5B). The p-value for three parameters show significant variation ($p < 0.05$). Recorded nutrients were higher for three sampling sites (sites 3, 2 and 4). This is because of direct effluent mix from various sources such as commercial and residential domestic wastewater including organic foods. As it moves from the upstream to downstream along the canal two shows a trend of reduction due to many factors such as sediment adsorption, reduction by chemical reaction, microbial activities, vegetation absorption, macro-invertebrate consumption and dilution. Similarly the mean values of pH were the same as to that of canal #1 (Fig. 5C). The minimum and maximum pHs 7.48–8.95 were record at site 14 and 2 respectively. The mean value of pH was significantly different among the sampling sites ($p < 0.05$). High pH was recorded at site two. The rising of pH at this site may be attributed the discharge of detergent waste water from *kebele* 16 condominium and from residence near by the drainage line.

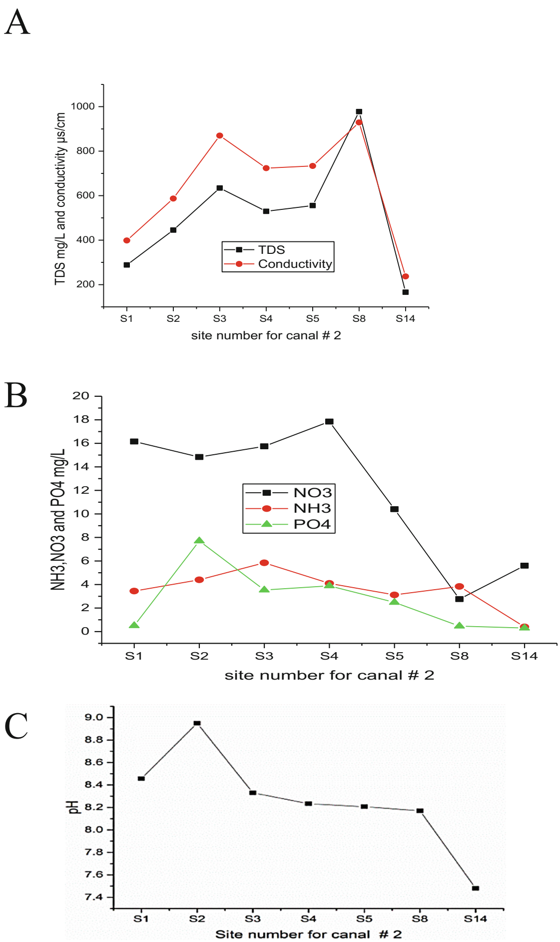

Fig. 5. TDS, conductivity, nutrients and pH variations for different sites of Canal #2.

3.5 Biological Oxygen Demand and Dissolved Oxygen for Blue Nile River Course

Table 4 presents values of water quality parameters for Bahir Dar municipal waste water drainage for. FAO and WHO maximum limits may be referred from Table 2.

In Table 4 and Fig. 6; the minimum and maximum average values of BOD (range from 15.7–33 mg/L) and DO (range from 5,9 – 5.01 mg/L) were recorded at sites 14 and 12 respectively. The p-value for both parameters show significant difference among the sampling sites ($p < 0.05$). The increment of BOD and reduction of dissolved oxygen were recorded at site 12. This reduction is as a result sediment addition and addition of organic matter in to Blue Nile river. Such as a direct effluent mix of organic waste from various sources mainly from residential and commercial centers along the main canal (including kebeles 08, 09 and 10), chimbile stream, car washing, by product

Table 4.

parameters	Site9	SitelO	Sitel 1	Site 12	Sitel 3	Sitel 4	value
BOD mg/L	15 ± 0.28	23 ± .21	27.89 ± .94	33 ± 0.8	15.7 ± 0.3	20 ± 0.35	0.05
DO mg/L	7.1 ± 0.01	7.25 ± 0.1	6.1 ± 0.06	5.0 ± 0.03	5.06 ± 0.1	5.9 ± 0.21	0.05
TDS mg/L	167.8 ± 3	165.3 ± 2	173.6 ± 2.7	175 ± 1.5	170.8 ± .7	166 ± 1.5	0.05
Conductivity' μs/cm	240 ± .28	243 ± 3	244 ± 2.9	269 ± 3.4	237 ± 2.5	245 ± 4.4	0.05
pH	7.74 ± 0.07	7.77 ± 0.6	8.1 ± 0.7	8.4 ± 0.04	7.74 ± .07	7.48 ± .07	0.05
NO_3 mg/L	2.5 ± 0.5	3.9 ± 0.4	4.65 ± 0.1	8.2 ± 0.7	6.68 ± .1	5.59 ± .04	0.05
PO_4 mg/L	0.1 ± 0.1	0.4 ± 0.01	0.13 ± 0.07	.3 ± 0.0	.35 ± .01	0.46 ± 01	0.05
NH_3 mg/L	0.2 ± .0	0.44 ± 0.03	0.14 ± 0.04	0.59 ± 0.02	0.45 ± .05	0.44 ± 0.2	0.05

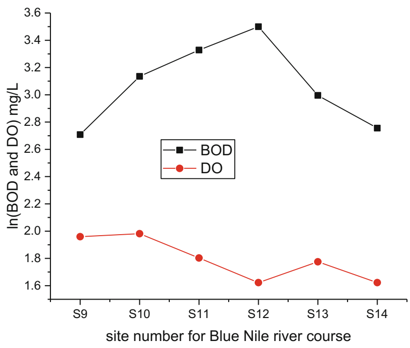

Fig. 6. Absolute value of BOD and DO versus site number for Blue Nile water course

from pig farm, and discharge of textile factory wastes. The drastic BOD reduction and enhancement of DO at site 14 is explained by ecosystem purification and dilution effect of the Blue Nile River.

3.6 TDS, Conductivity, Nutrients and PH Variations for Blue Nile River Course

The minimum and maximum average values of TDS (range from 166–175 mg/L) and electrical conductivity (range from 237–269 µs/cm) were recorded at site 14 and 12 respectively (Fig. 7A). The p-value for both parameters show significant difference among the sampling sites ($p < 0.05$). The maximum values for both parameters were recorded in site 12 where higher concentration due to the collected effluents of wastewater from hotels, residents (*kebele* 9, 10 and 11) garages, Textile waste water discharge, storm water on both side of the river, storm water from Chimbil stream and by product from farm land near to Blue Nile river.

Ammonia, nitrate and phosphate concentration ranges from 0.14–0.49 mg/L, 5.9–8.2 mg/L, and 0.3–0.47 mg/L, respectively (Fig. 7B). Recorded nutrients were higher in site 13, 12, and 11 respectively. This is because of direct effluent mix from various sources such as residential domestic wastewater including organic foods, byproduct from pig farm and textile factory discharging of waste water. As it moves from the upstream to downstream along the canal shows a trend of reduction due to many factors such as sediment adsorption, redox chemical reaction, microbial activities, vegetation absorption, macro-invertebrate consumption and dilution. The pH mean value ranges 7.48–8.4 were recorded at site 14 and 12 (Fig. 7C). The mean value was significantly different among the sampling sites ($p < 0.05$). High pH was recorded at site twelve. The rising of pH at this site may be attributed the discharge of waste water from textile industry and cloth washing by local people near to the Blue Nile river.

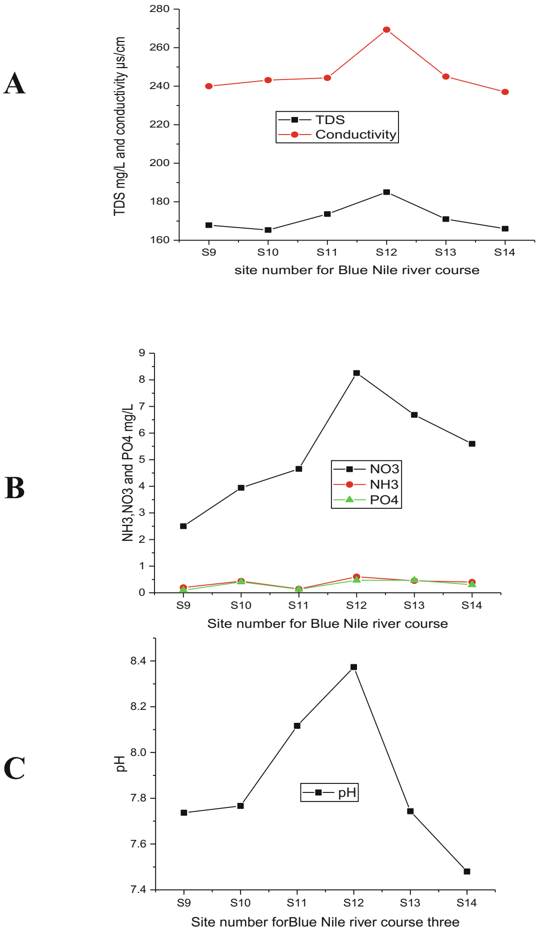

Fig. 7. TDS, conductivity, nutrients and pH variations for different sites of Blue Nile water course

Summary Results

Ecosystems reduced BOD, TDS, Conductivity, pH, NO_3, PO_4, and NH_3 reduced by 66.6%, 75%, 75.5%, 16.4%, 62.5%, 95.4%, 92.4% and increased DO by 70% in waste water drainage canal #1

Ecosystems reduced BOD, TDS, Conductivity, pH, NO_3, PO_4 and NH_3 by 55.5%, 83%, 73.6%, 16.4%, 62.5%, 95.4%, 92.4% and DO increased by 70% In waste water drainage canal #2.

In Lake Tana and Blue Nile river line, BOD, TDS, Conductivity, pH, NO_3, PO_4, and NH_3 was reduced by 52.2%, 5%, 11.89%, 7.85%, 31.83%, 34.8%, 16.95% respectively. while DO was reduced by 18%.

4 Conclusions

Ecosystem purification did not improve conditions of BOD and DO to proximity to FAO and WHO standards.

Even though ecosystem purification and dilution helped improve other water quality indication for both drainage lines, results were found to be under FAO and WHO standards.

With current ecosystem purification, most water quality parameters of effluents at site 14 except BOD & DO were within acceptable levels set by international standards for effluents to be discharged to surface water and FAO maximum permissible level set for waste water to be used for irrigation purposes.

But some water quality parameters of the head of Blue Nile River were above WHO maximum permissible level set for drinking purposes.

Recommendations

To reverse the adverse outcomes of effluents, treating wastes and minimizing their adverse effect on environment the Administration Office of Bahir Dar, community, and institution need to preserve the ecosystem.

Bahir Dar University should develop institutional wastewater treatment plants and management systems to provide clean water to downstream populations and mitigate impacts of development that.

References

1. Mehari, A.K., Gebremedhin, S., Ayele, B.: Effect of Bahir Dar municipal effluents on water quality of the head of Blue Nile River, Ethiopian. J. Environ. Stud. Manage. **9**, 197–208 (2016)
2. Smit, J., Nasr, J., Ratta, A.: Urban agriculture: food, jobs and sustainable cities. New York, USA **2**, 35–37 (1996)
3. Campbell, H.E., Corley, E.A.: Water, pp. 185–216. Urban Environmental Policy Analysis, Routledge (2015)
4. Melaku, S., Wondimu, T., Dams, R., Moens, L: Pollution status of Tinishu Akaki River and its tributaries (Ethiopia) evaluated using physico-chemical parameters, major ions, and nutrients. Bull. Chem. Soc. Ethiopia **21** (2007)
5. Davis, S., Golladay, S.W., Vellidis, G., Pringle, C.M.: Macroinvertebrate biomonitoring in intermittent coastal plain streams impacted by animal agriculture. J. Environ. Qual. **32**, 1036–1043 (2003)
6. EPA U: Guidance on cumulative risk assessment of pesticide chemicals that have a common mechanism of toxicity. Office of Pesticide Programs (2002)
7. Mandaville S: Benthic macroinvertebrates in freshwaters: Taxa tolerance values, metrics, and protocols: Citeseer (2002)
8. Berhe, T.: The degradation of the Abo-Kebena River in Addis Ababa, Ethiopia. M. Sc Thesis, school of Graduates Studies, Addis Ababa University (1988)
9. Mehari, A.K., Wondie, A., Mingist, M., Vijverberg, J.: Spatial and seasonal variation in the macro-invertebrates and physico-chemical parameters of the Enfranz River, Lake Tana sub-basin (Ethiopia). Ecohydrol. Hydrobiol. **14**, 304–312 (2014)

10. Misganaw, T.: Assessment of the ecological impacts of floriculture Industries using physico-chemical parameters and benthic macroinvertebrates metric index along Wedecha River, p. 185. Addis Ababa University, Addis Ababa, Debrezeit (2007)
11. Wosnie, A., Wondie, A.: Assessment of downstream impact of Bahir Dar tannery effluent on the head of Blue Nile River using macroinvertebrates as bioindicators. Int. J. Biodivers. Conserv. **6**, 342–350 (2014)
12. Teferra, A.S., Alemu, F.M., Woldeyohannes, S.M.: Institutional delivery service utilization and associated factors among mothers who gave birth in the last 12 months in Sekela District, North West of Ethiopia: a community-based cross sectional study. BMC Pregnancy Childbirth **12**, 74 (2012)
13. Jain, C., Bhatia, K.: Physico-chemical analysis of water and wastewater. User's manual UM-26, Roorkee: Nat. Inst. Hydrol. (1987)
14. Dagne, M.: Performance Evaluation of Kality Wastewater Stabilization Ponds for the Treatment of Municipal Sewage, from the City of Addis Ababa, Ethiopia, Addis Ababa University (2010)