AES BIOFLUX

Advances in Environmental Sciences - International Journal of the Bioflux Society

Soil and stream water quality along Digkila-an and Dodiongan tributaries of Mandulog Watershed, Iligan City, Philippines

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Abstract. Watersheds may undergo significant changes due to natural disasters and anthropogenic impacts. Adverse effects on the watershed quality can be mostly due to human activities like improper land use and agricultural practices. The lack of proper implementation of watershed policies and guidelines would lead to unsustainable agricultural practices and other activities in the watershed. Such is the case in the Mandulog Watershed in ligan City. After the devastating super typhoon "Sendong" in December 2011, the researchers aimed to document initial assessment of the current status of soil and stream water quality at the lower stream area of the Mandulog Watershed, which are the Digkilaan and Dodiongan barangays, as the study area. The results of analysis revealed that the soil quality in these study areas is still in its adequate and healthy vegetative status. The values of the chemical parameters obtained are still in its normal range, up to this study. However, it was evident that, majority of the streams and creeks have reduced in size due to loss of water. Results of this research revealed that based on physico-chemical analysis, the soil quality in the study area is still in its adequate and fertile state. The type of soil obtained from the six sampling sites was mostly clay-loamy which indicated that it has adequate amount of organic matter content (2.85-3.54 ppm). It could also imply that the soil has high capacity for water retention and buffering capability, thus delaying the soil acidity that could be brought about by fertilizer inputs. It is evident from the normal pH range among all soil samples, at an average of 6.0-7.3. Phosphorus content was at its moderate range of 6.83-9.50 ppm. The potassium content is still in the adequate range of 0.33-0.43 ppm. Result of analysis of stream water samples revealed that base on pH range (7.8-8.1), the streams are still in its healthy state. Conductivity values were at normal range indicating that there was no sign of dissolved heavy metals. The nitrate and phosphate content in all samples were within the normal range. It is a good indication that the streams are not threatened by eutrophication due to agricultural runoff. Despite the normal values of the parameters it was very noticeable that the stream water segments in the study area decreased significantly. There is a possibility that a large volume of the stream at the upstream has been utilized for irrigation.

Key Words: Anthropogenic impacts, watershed policies, soil quality, agricultural practices.

Introduction. Watersheds may undergo significant changes which are caused by either natural or human influences. Storm (such as the super typhoon *Sendong*, flood, and erosion are just few of the natural events that can influence watershed changes. Adverse effects of increasing population and human activities such as land use (Wang et al 1997), agricultural and logging practices can largely contribute to such changes that can lead to deterioration of watersheds. The influx of the fertilizer (Hatfield et al 1999) and pesticide residues (Di & Aylmore 1997) into stream water can sip into aquifers and water table (EPA 2014). The physical and biological characteristics continuously change and evolve with time so that even in the absence of anthropogenic activities, the watershed would still undergo changes. Periodic natural disturbance is necessary for nutrient cycling throughout the watershed. Watersheds have the ability to evolve over a certain period of time while self-regulating after disturbances (Steedman & Regier 1990). However, the degree of watershed stress can be detrimental to a large extent with the impact of climate change (Ahmadi et al 2014) interplaying with anthropogenic effects. One of the major indicators of watershed's health is its soil and water quality. Assessment of the quality of soil and water, through its biological and physico-chemical parameters, has always been and urgent process of determining extent of effects of natural disasters and anthropological impacts.

The large tributaries (barangay Digkilaan and barangay Dodiongan) of the Mandulog Watershed are the area where a large portion of agricultural field is located. Agricultural inputs just runoff the stream water due to absence of proper drainage. Thus, evaluation of the physico-chemical characteristics of soil and stream water along the area is a proactive move in order to determine, at the earliest stage, the impact on the health of the watershed and its environment. This is an urgent step towards gauging local government units to come up with sustainable watershed guidelines and policies. Engaging the local government unit and the local community would effectively minimize degradation of soil resources and the implication of those deteriorating changes for environmental health (Karlen et al 2014).

Material and Method. Soil and stream water quality were determined from the samples obtained by composite sampling technique. The soil samples were obtained from Digkilaan and Dodiongan areas, during fair-weather conditions on the second week of August, 2013. These areas are at the lower stream of the entire Mandulog Watershed. The corresponding GPS coordinates described in Table 1. For soil analysis, the parameters included were pH, organic matter content, phosphorous and potassium content. Collection of stream water samples were done during sustained fair-weather stream flow conditions on the second week of August, 2013. Water samples were collected at single points (at the centroid flow of the stream of which dissolved constituent concentrations are assumed to be uniform across the cross-sections) (Martin et al 1992). Sampling stations were 100 m away from each other (USEPA 1997). The water samples were analyzed for pH, nitrates, total phosphate, conductivity and total dissolved solids. All chemical analysis was determined following standard protocols (USEPA 2012; APHA 1992). Visual inspection on the quality of stream waters at the sampling site was also conducted (Harmel et al 2006). Biological parameters, heavy metal and pesticide residue content were not yet included due to limited funds. All data were subjected to statistical treatment (ANOVA).

Results and Discussion. The results of analysis of the representative samples obtained are shown in Table 1. All soil samples collected were clayish and loamy which could indicate the soil samples contain higher amount of organic matter, has high water retention and is very suitable for vegetation (Mitchell & Soga 2005).

Table 1

Description of soil sampling stations within the Digkilaan-Dodiongan Watershed

Sampling station	*GPS coordinates*	*Visual description*
S1	08.25238 N ; 124.31653 E	clay-loam; porous
S2	08.25222 N ; 124.31736 E	clay-loam; porous
S3	08.25678 N ; 124.27356 E	silt-clay; porous
S4	08.23997 N ; 124.31455 E	clay-loam; porous
S5	08.24017 N ; 124.31493 E	silt-clay; porous
S6	08.23953 N ; 124.31424 E	clay-loam; porous

The results of soil analysis are shown in Table 2. The pH of the soil samples ranged between 6.0–7.3. This could imply that the watershed area can still be considered as favorable for vegetation. This pH range is considered the normal condition for a healthy soil. This range is favorable for growth of microorganisms that can aid in making the soil nutrients available for plants. Although, one of the soil samples (S5) has pH less than

6.0, which is relatively acidic than the rest of the samples. It can also imply that potassium is less available than those at the other sampling sites. This is consistent with the value of available potassium in the same sampling station. Compared to the other sampling stations, the amount of available potassium is relatively smaller.

Table 2

Results of analysis of soil samples from Digkilaan – Dodiongan Watershed

Sample code	*pH*	*Organic matter (ppm)*	*Phosphorus (ppm)*	*Potassium (Ppm)*
S1	6.8	2.85 (A)	7.54 (M)	0.35 (A)
S2	6.1	3.54 (A)	6.83 (M)	0.38 (A)
S3	7.3	1.56 (D)	9.50 (M)	0.43 (A)
S4	7.1	2.40 (A)	9.00 (M)	0.38 (A)
S5	5.8	1.85 (D)	8.42 (M)	0.33 (A)
S6	6.9	3.20 (A)	7.82 (M)	0.40 (A)

A – Adequate, M - Moderate; D – Deficient.

The amount of phosphorus in the soil samples is in the range of 6.83–9.50. Based on standards, it is considered of marginal range, which could imply that it can still provide the some amounts of phosphorus needed by the plants. However, fertilization would be necessary to enhance its phosphorus content in the soil. As shown in Table 2, four soil samples (S1, 2, 4 & 6) contained adequate amounts of organic matter, ranging from 2.85 to 3.54. The loamy characteristic of these soil samples can confirm that this sites are humous, indicating that it is very good for vegetation. High organic matter content is indicative of its being profitable since it can improve soil productivity resulting in good farm production (Cornell University 2008). It has high capacity of holding water (USDA-NRCS 2014). Over a period of time, it can supply essential nutrients (such as Ca, Mg and K). Organic matter also acts as a buffer making the soil resistive to rapid change in pH, at the same time delays soil acidification especially in agricultural areas that largely depend on fertilization.

The description of the stream waters obtained from different sampling sites in Dodiongan and Digkilaan Rivers are shown in Table 3. It was observed that the stream water sampling sites were very shallow. The river beds were sandy and the waters were clear. Based on interviews with the locals, the streams would turn very turbid during rainy seasons or when there is flood from the upstream.

Table 3

Description of sampling stations for stream water along the Digkilaan–Dodiongan Watershed

Sample code	*GPS coordinates*	*Visual description*
	Dodiongan River	
S1	08.26975 N ; 124.29091E	clear; sandy river bed; knee – deep
S2	08.26973 N ; 124.29127E	clear; sandy river bed; knee – deep
S3	08.26969 N ; 124.29148E	clear; sandy river bed; knee – deep
	Digkilaan River	
S4	08.25238 N; 124.31653 E	slightly turbid; sandy river bed; knee – deep
S5	08.25222 N; 124.31736 E	slightly turbid; sandy, slightly silted river bed; chest – deep
S6	08.25308 N; 124.31776 E	slightly turbid; sandy, slightly silted river bed; chest – deep
S7	08.25051 N; 124.31846 E	slightly turbid; sandy river bed; knee – deep

Table 4 shows the results of analysis of the water samples collected in the stream segments along the Dodiongan River contained total nitrates at a range of 7.8–7.9, while that from the Digkilaan River has a range of 2.6–2.8. Base on standard values of parameters for stream waters, the nitrate content is within the normal range (Watershed Council 2014).

Table 4

Chemical parameters in stream water samples from Digkilaan – Dodiongan Watershed (Water temp: 28°C)

Sampling site	*pH*	*Nitrates (mg/L)*	*Phosphate (mg/L)*	*Conductivity (µS/cm)*	*TDS (mg/L)*
Dodiongan River					
S1	7.9	3.4	0.2505	0.35	230
S2	7.8	3.5	0.2466	0.38	228
S3	7.9	3.2	0.1310	0.43	242
Digkilaan River					
S1	8.1	2.8	0.2254	0.37	235
S2	7.9	2.7	0.3469	0.40	220
S3	8.0	2.8	0.1310	0.40	233
S4	7.9	2.6	0.1889	0.37	239

TDS - Total Dissolved Solids.

The phosphate content of the water samples obtained from stream segments along the Dodiongan River is in the range of 0.1310–0.2505 ppm while that of the water samples obtained along the Digkilaan Rivers is in the range of 0.1310-3469 ppm. This result implies that there is no excessive agricultural runoff. This also indicates that currently, there is no danger of eutrophication and subsequent degradation of stream water quality. The conductivity values of the stream water samples obtained from Dodiongan River is at the range of 0.35–0.43 µS/cm while that from the Digkilaan River is at the range of 0.37–0.40 µS/cm. Both ranges of conductivity indicate that there is no significant amount of dissolved ions and no dissociated inorganic compounds along the stream waters (Watershed Council 2014). Also, it can be deduced that there has been no significant presence of heavy metal ions along the stream segments and from the upstreams.

The values of the total dissolved solids in stream water samples obtained from the stream segments of Dodiongan and Digkilaan River ranged from 220–242 ppm. This is still within the normal range. This can indicate that there is no danger of eutrophication (Watershed Council 2014). Although, based on Table 3, the water obtained from Digkilaan stream segments were slightly turbid, but it has no significant impact on the conductivity of the water. It is also an indication that there are no excessive agricultural activities, such as over fertilization on the crop lands as well as no dredging and mining occurred in the upstreams.

Conclusions. Base on the results and analysis of the data obtained at the Digkilaan-Dodiongan tributaries this study can be characterized as healthy watershed, in terms of its land quality, land cover and soil and stream water quality. It is a potential source for potable water supply system for the locals. The relatively low nitrate and phosphate content of the stream water samples can indicate that the study area has no sign of eutrophication in its stream waters. Also, it can be a confirmation that there has been a minimal input of nutrients from fertilizer and animal waste runoffs from the agricultural areas. This is also confirmed by the absence of aquatic plants or plant detritus in the stream. As of this study, there would be no danger of depletion of dissolved oxygen. Its land is still covered with plant organisms that can contributing to the increase in organic matter content in the soil, thus making the soil vegetative and suitable for agriculture.

Acknowledgements. The researchers are grateful to the localities along the Mandulog Watershed communities, to the City Planning and Development Office (CPDO) of Iligan

City, to the Department of Chemistry of MSU-IIT, to Prof. Ed Aranico and Prof. Dan Mero for their guidance and technical support, and to our mentor Dr. Annielyn D. Tampus for her encouragement.

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Rceived: 04 December 2014. Accepted: 06 January 2015 Published online: 30 January 2015.
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How to cite this article:
Almeda M. C. V., Monteron M. O., Benecario J., Bitantos B., Adiong S. K., Seniel J. G., Tampus A. D., 2015 Soil and streamwater quality along Digkila-an and Dodiongan tributaries of Mandulog Watershed, Iligan City, Philippines. AES Bioflux 7(1):35-40.