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Water quality and physical assessment of sungkilaw waterfalls in Zamboanga Norte, Philippines

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Abstract

Zamboanga del Norte is often considered enigmatic as it has several secret mysteries waiting to be found. Sungkilaw Falls in Zamboanga Norte, Philippines is now listed as a tourist destination as it has proved to be one of Zamboanga Peninsula's most famous tourist destinations. This study considered three streams using a single sampling technique to assess the falls physical features and water quality initially. Studied water quality parameters were pH, temperature, biochemical oxygen demand (BOD), turbidity, total dissolved solids (TDS) using pre-calibrated portable meters. Total and faecal coliforms were also determined using Multiple Tube Fermentation Technique to find out the presence of a member of the coliform group in groundwater and surface water. Overall, Sungkilaw falls water quality parameters are within the normal limit of DENR standard showing no potential pollution. Presence of coliforms was detected in the bacteriological analysis of the water samples in all sampling stations. These results are possible because of the wastes that leach from industrial, animal and domestic sewage in the streams. Present findings are preliminary and further analyses and monitoring may be essential.

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Introduction

Waterfalls are exciting landforms that set the speed of landscape development as a consequence of the incision of the bedrock (DiBiase, 2015). They convey shifts in sea level or tectonic elevation in the environments or isolate the ecosystems from downstream disruptions (DiBiase, 2015; Scheingross, & Lamb, 2017). A waterfall is a place where a stream or river falls from a high place example over a cliff or rock (Scheingross., Lamb & Fuller, 2019). It is caused by gravity taking its effect on water and pulls it down a cliff (Chernicoff *et al.*, 1997; Frost & Frost, 2019). A large amount of stream energy is expended at waterfalls. Waterfalls are associated with "tier," a free-fall water drop, beginning when the water leaves the bed of the river or contact with the rock and ends when the water hits a rock or the bed of the river again (Chester *et al.*, 1999; DiBiase *et al.*, 2015).

In Africa, the reason is that waterfalls were named after deities and were used as places of traditional and ancestral worships. In other areas, the intensity of waterfalls and pressure generated from it due to gravity has given the impression of a lifeless zone (Chernicoff *et al.*, 1997; Lawson, Hung, & le Roux, 2017). Knowledge of waterfalls systems are therefore limited to hydrology and geological features (Chester *et al.*, 1999; Fischer and Harris, 2003; Visto, Nuñeza, & Magdamit, 2015), as natural monuments for revenue generation, because of their ecotourism potentials and as a source for drinking, irrigation and other domestic purposes.

Zamboanga del Norte is often considered enigmatic as it has several secret mysteries waiting to be found. One such marvel was Sungkilaw Drop, which is situated in the barangay of Diwan, Zamboanga del Norte, in the city of Dipolog. The site is established by the local government and sponsored by the neighbouring Subanen, a peace-loving indigenous community (Thapa 2019). The total energy of nature from such a distance, when white water comes down against the side of a damp rock formation and flows violently into the waiting tub, with nebula bringing mystique to the vision. A neighbouring observation deck offers us a perfect view to fully enjoy the whole fall. A track of stairs descending through the duration of the fall is some distance ahead. At the foundation, there is a tank where the water is stored until it is emitted again. In this place, visitors can swim upstream in the clear cold water from the many natural springs.

(Hudson, 2016) Sungkilaw is the most remote Barangay of the City of Dipolog, in Sitio Virginia, Barangay Diwan, 25 foot high waterfalls. Dotted with true nature charm, tourists and guests will enjoy it. In the centre of the overgrown jungle, the natural gift and moving closer to the falls would take an invigorating walk to some 410 descending steps over green trees, flora and fauna. Sungkilaw Falls is the best location to explore and take part in some of the most exciting activities and experiences such as rappelling, canoeing and diving (Hudson, 2016). As a tourist destination in the city, a need to secure its water quality is essential. In the past, this area had experienced typhoons and flash floods. However, no available studies were conducted to evaluate present arrangements to sustain river water quality. Pule, Yahya, & Chuma, 2017)

The objectives were to determine the overall physical features and water quality parameters of Sungkilaw falls, and the utilization of waterfalls by nearby communities and can provide results to tourists that suggest the place has good water quality, which makes this study very significant. Specifically, it aims to: (1) Determine the characteristics of Sungkilaw falls in terms of the following: (a) over-all features of the falls in terms of the height of the falls; width; surface area of the plunge pool; depth; water current; volume, (b) Water Quality of the Plunge Pool: (b.1) Physico-chemical characteristics as to pH, temperature, turbidity, TSS, TDS, BOD, and Cl, (b.2) Total Coliform and Fecal Coliform; and (c) Utilization of the Waterfalls by the nearby communities.

Materials and methods

This study is anchored on monitoring and assessment of water health quality in the Tajan River, Iran using physicochemical, fish and macroinvertebrates indices of Aazami (2015) that among various ecosystems in the world, rivers which cross different areas such as agriculture and industry are the most threatened and affected by anthropogenic activities. Water contamination is a severe and pervasive concern in developed countries such as Iran (Noorhosseini *et al*., 2017). Water supply management of rivers is therefore very critical and especially essential for semi-arid and developing countries. Assessing and classifying the aquatic water quality using indirect methods will lead to river restoration and management (Wu *et al*., 2018).

Measuring physicochemical parameters usually is time-consuming, costly and often based on special instruments. Nevertheless, at the point of calculation, physicochemical measurements will only indicate water content, and that will vary with a point. Currently, metrics focused on aquatic organisms 'existence or absence have been created to assess water quality and to identify ecological status.

Sampling site

The study was conducted in a 42.5 feet high waterfall situated in Sitio Virginia, Barangay Diwan, the farthest barangay of the city (Latitudes $8^0 21` 14.78846``$; Longitude $123^0$ $21` 37.4860``$) (Fig. 1). The natural phenomenon is located in the middle of the dense jungle, and the brave would require a trek of about 400 descending steps over green trees, flora or fauna.

The coordinates of the study site were identified using the total station NTS 332R model (Table 1).

Table 1. Description of a studied waterfall in Barangay Diwan, Cogon, Dipolog City.

Falls	Latitude	Longitude
Sungkilaw Waterfalls	$8^0 21` 14.78846``$	123^0 $21` 37.4860``$

A

B

C

Fig. 1. a) Lower Stream, b) Middle Stream, and c) Upper Stream.

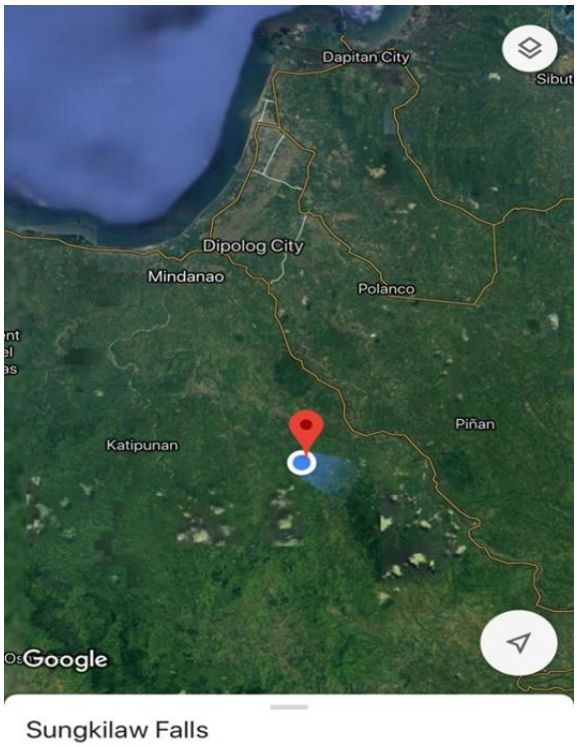

Fig. 2. Map of the Brgy research site. Cogon, Village of Dipologue.

Sampling technique

One grab sampling on November 15, 2019 was employed in this study. The researchers follow scientific steps in handling water samples by using sterilized bottled containers where the sample were placed and maintained the water temperature to avoid contamination. Upon sampling, the containers were washed three times with the river water before sample collection. Surface river waters were taken from three sampling stations 3 meters from the above ground. The analyte was transported to the testing centre for water analysis.

Determining the physical features of the falls

The total station (south) NTS-332 R model was used to determine the height, width, surface area, depth and volume of the three stations (lower stream, middle stream and upper stream).

Waterfall Current

To determine the water current of the falls mark a spot in the water as the starting point and endpoint. Have the Styrofoam float ready and start zero minutes upon releasing it on starting point.

Stop the timer when the float reaches the intended finish line. Calculate the rate of the water current.

Water Quality of the Plunge Pool and Different Zones

Physico-chemical analyses

Determination of pH

the pH of the samples was determined against pH 4 and pH 7 in an Oakton pH700 pH meter equipped with an automatic temperature compensation probe, respectively in three replications.

Turbidity

Water turbidity was determined nephelometrically with a Merck Turbiquant 1500T in three replications.

Temperature

Water temperature was measured by a water thermometer.

Total Suspended Solid (TSS)

One-litre samples in three replications were collected in each of the sampling station. In the laboratory, water samples were filtered through preweighed GF/C and dried. The filters were pre-stabilized, weighed before filtration. After filtration, the residue was air-dried at 110°C a GF/C filter for one hour to constant dry weight and weighed again.

$$\text{TSS, mg/L} = \frac{weight\ of\ solids\ in\ mg}{volume\ of\ sample\ in\ L}$$

Total Dissolved Solids (TDS)

Fifty mL of the filtrate from TSS was pipetted into dry pre-weighed 50mL beakers. The water was evaporated to almost dryness and finally dried at 110^0C. The dried residue is reported as the total dissolved solids.

BOD. Two sets of BOD bottles were dipped into the water and covered when full while still immersed in the water. At Day 0 (initial DO determination), oxygen was fixed by treating the samples with MnSO4 and alkaline KI right away and covered with dark plastic bags. Winkler titration was done on-field

working station. The second bottle was incubated for 5 days and dissolved oxygen was then determined. BOD was then calculated as DO0-DO5.

Chloride. Sample was titrated with AgNO3 using sodium chromate as indicator (Mohr method).

Bacteriological Determination

Total Coliforms/Fecal Coliforms Analysis

Multiple Tube Fermentation Technique is used to determine the presence of a member of the coliform group in groundwater and surface water. Water samples (100 mL each) were collected using a sterile sampling bottle and processed using the membrane filtration method for coliform analysis. Coliform was cultured in endobroth medium at 35˚ C for 48 hours. The colonies were counted and recorded. The most probable number (MPN) of colonies per 100 mL of seawater was determined using the formula:

$$\text{MPN/100 mL} = \frac{\text{No. of Colonies}}{\text{Volume of water sample in mL}} \text{ x } 100$$

Results and discussion

Overall Physical Features of the Waterfalls

The overall physical features of the waterfalls were determined like height, width, surface area, depth, water current and volume.

Table 2. Summary of the physical features of Sungkilaw falls.

Physical features	Upper stream	Middle stream	Lower stream
Height	39.68 m	71.86 m	7.8 m
Width	12.33 m	10.66 m	7.6 m
Surface area	411.21 sq.m	161.66 sq.m.	36.30 sq.m.
Depth	0.55 m	0.77 m	12.95 m
Current	0.37 m/s	0.42 m/s	3.60 m/s
Volume	226.17m^3	124.49 m^3	470.24 m^3

Physico-chemical analyses

The overall Physico-chemical parameters were comparable. Both temperatures are on the same scale (26-27 0C) and pH (7-8). The TSS (total suspended solids) was considerably large in the upper station, but in the DENR norm. The current results were accepted with studies performed on stream waters in Tiwari *et al*. (2017) and Issaka *et al*. (2016) which showed a strong association between TDS and turbidity and conductivity. Such conditions, however, were within the usual range.

Table 3. Summary of the physicochemical analyses of Sungkilaw falls.

Parameter	Waterfalls Standard				
	stream PNSDW	Upper	Middle stream	Lower stream	DENR
pH	7.82	7.84	7.85	6.5-8.5	6.5-8.5
Temperature	26.3^{0}C	26.4^{0}C	26.8^{0}C	26-30	27
Turbidity	0.33	0.33	0.36	-	5
TSS	0.90	0.6	0.6	65	N/A
TDS	6.8	7.0	6.0	500	500
BOD	0.36	0.29	0.27	5	N/A
Cl	6.34	6.34	6.83	250	200

Bacteriological analyses

Coliform contamination. Total faecal coliforms, as described in Table 4 is positive for the outcome of the bacteriological study of water samples at all sampling stations. Water samples from sapa lawaan situated near the central stream station had the lowest total count of coliforms yet surpassed DENR. In coliforms, on the other side, the highest count was contained in water samples from the middle stream station, while the lowest count was 1.1MPN/100 ml for salty water (miraculous). Such effects are possible due to pollution leaching from chemical, animal and domestic runoff in waterways.

Table 4. Bacteriological analysis of Sungkilaw falls.

Sampling point Remarks	Physical	HPC CFU/ml	Total Coliforms MPN/100ml	Thermotolerant (Fecal) Coliforms MPN/100ml
Lower stream Middle stream	Colorless,clear Failed	954	8.0	2.6
Upper stream Sapa Lawaan	Colorless,clear Failed	72	8.0	8.0
Salty water(miraculous)	Colorless,clear Failed	1026	8.0	2.6
PNSDW 2017, DOH	Colorless,clear	127	2.6	2.6

AO 2017-0010	Failed			
Standard	Colorless,clear	97	4.6	1.1
	Failed			
		<500	<1.1	<1.1

Utilization of the waterfalls by the community

Human activities in natural environments are among the most important recreational needs. Monthly studies of tourism characteristics was conducted during wet and dry seasons, over a two year period in the three landscapes along the 6817.7m length of Agbokim waterfalls by using a close-ended pre-coded survey instrument. Qiu, & Wang, 2015 found out that through MANOVA analysis of the 1780 respondents have strong positive association between people's visits to the recreational areas and the type of landscape in which the respondents felt happy.

Actual interviews to the residents were made by the researchers. Most of them gave positive impacts as to usability of the falls to their daily activities such as bathing, laundry, swimming, tourist guiding, host for girl scout encampment and source of herbal plants and IP's handicrafts (nito). "This is the only tourist destination without an entrance fee. There are native crops the visitors could buy and it's a tourist attraction where one should not miss to visit," said Mrs. Turno, Brgy. Chairman of Barangay Diwan. Moreover, the residents added that during holy week, the salty water was often visited since it is known for its miraculous contribution to the health of some visitors and tourists.

Water pollution assessment is generally focused towards physical and chemical parameters whereas biological aspects were given little attention until recently Zoeteman (2015) summarized various reasons for exclusion of assessment in water pollution. Although physical and chemical methods of assessing water pollution are relatively simple to interpret, biological assessment has many strong merits (Cairns, *et al.*, 1976; Cairns and Van Der Schalie, 1980; Effendi, 2016.).

Conclusion

The implications of water standards on health are enormous. Every parameter of water has a safety implication. Therefore, consumption of water of poor quality can lead to serious health problems. Some health effects may be immediate; others may be more devastating due to cumulating toxic chemicals. Ignorance or poverty cannot prevent morbidity or mortality associated with unsafe water only enlightenment does. Monitoring, surveillance and control of water standards remain cardinal for ensuring optimal public health. A comparison of the results of the physiochemical analysis and bacteriological analysis of the water samples collected from the study area showed that the water in the study areas have no permanent chemically induced colour, they are tasteless and odourless and are neutral to slightly alkaline. However, the chloride content in the samples gives an indication of fecal pollution in the water; this is reflected in the bacteriological analytical method employed which showed that the water in the study area is contaminated with fecal coliform. It can be inferred that water chemistry is based on the composition of the groundwater, water absorption, ion exchange with the reservoir rock, human activity and effluent dumping on streams and rivers (Ayodele, 2015). The parameters analyzed demonstrated minor differences at the three locations (upper, middle and lower). Overall study of waterfall efficiency was performed according to requirements. Nevertheless, the presence of coliforms suggesting that the water needs adequate handling and calming steps was found in the bacteriological study. Current reports are tentative and further analyzes can be required.

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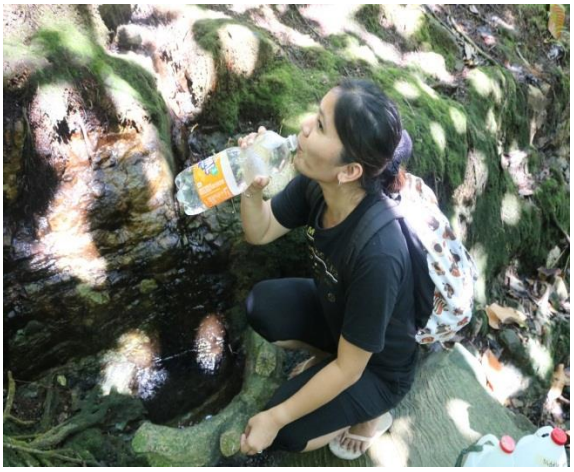
Pictures from field of work or laboratory work

Determining the water current of the middle stream

Determining the location of the study site using Total Station



Drinking the salty water sample known as the "Miraculous Water" near the middle stream