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Research article

Estimates of Liquid Waste Deposition to Layawan River System, Mindanao, Philippines

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Abstract

Liquid wastes from anthropogenic-based activities may deteriorate the quality of a river system that in turn may impair its socio-economic and ecological significance. Hence, a study on estimates of liquid wastes deposition at Layawan River was conducted. This is in response to its current status as the cleanest and greenest river in Philippine region. Six barangays were considered that represented the upstream, midstream and downstream portions of the river system. In-person interviews using survey questionnaires and secondary data were used. Results showed that bulk of organic wastes (99%) from domestic activities comprised food and utensils washings using soaps and detergents. Agricultural wastes contained minor chemical wastes (45% t0 69%) from synthetic pesticides and fertilizers while some wastes were generated from poultry and swine production. Eroded soils from quarry activities were contributing water turbidity. Statistically, liquid wastes were significantly (p value < 0.05) contributing water pollution to Layawan River system. Results might contribute significant information to the local government and other stakeholders for immediate conservation and management of the river system for the present and future generations.

Keywords: LayawanRiver, watershed,liquid waste, Oroquieta City, sustainable development

Introduction

Layawan watershed is one of the 15 major watersheds in Mt. Malindang Range. It is a major rain-catchment area in Zamboanga Peninsula that supplies water to the provinces of Misamis Occidental, Zamboangadel Sur, and Zamboanga del Norte (Baretto et al., 2006). Its headwaters are located in Brgy. Sebucal and has a highest elevation at the North Peak reaching up to 2 183 masl. Water from Layawan watershed is mainly used for domestic and

agricultural activities among the 33 barangays covered. Over the years, the watershed has been exposed to destructive activities such as illegal logging, encroachment, and timber poaching. The declaration of Mt. Malindang as a protected area (RA 9304) reduced destructive activities in the upland portion of the watershed, hence its eventual conservation. Water quality problems were observed in the low land portion of the city due to improper farming practices in the midland and lowland portion of the watershed. Anthropogenic wastes were also observed in certain parts of the river bank. This poses a huge threat to the residents of Oroquieta City as primary dependents of the water for various socio-economic uses (Calderon M., et al 2012).
Layawan River is a recipient of cleanest and greenest river award in the Philippines. However, continuing threats of water quality deterioration is prevalent particularly the liquid wastes that are freely draining into the river system. Hence, this study was conducted to help the local government and other concerned stakeholders to do holistic and concerted efforts on conservation, protection and management of the river system. The estimates of liquid wastes drained into the river system could be an added significant information needed to immediately address this issue.

Materials and Methods

Preliminaries Prior to Data Gathering

Prior to actual survey and interview, an entry protocol visit to the City Government of Oroquieta was done to explain the objectives of the study and to obtain permission to conduct the study in the different barangays comprising the upstream, midstream and downstream portions of the river system. This ensured support and cooperation of the LGU especially in giving information and in making data available from their units.Sampling of respondents were done in selected residents at downstream barangays of Poblacion II and Taboc Norte,in midstream barangays of Bunga and Buntawan, and in the upstream barangays of Toliyok and Mialen.

Data Gathering and Management

Data gathering employed household survey, key informant interviews, focused group discussions and geotagging.Available secondary data were obtained from the City Planning and Development Office, City Environment and Natural Resources Office, Barangay Profile and from other reliable sources.

Respondents in this context of study were selected based on the barangay profile especially on the distance of the household from the Layawan river and their various activities that contribute sources of liquid wastes.

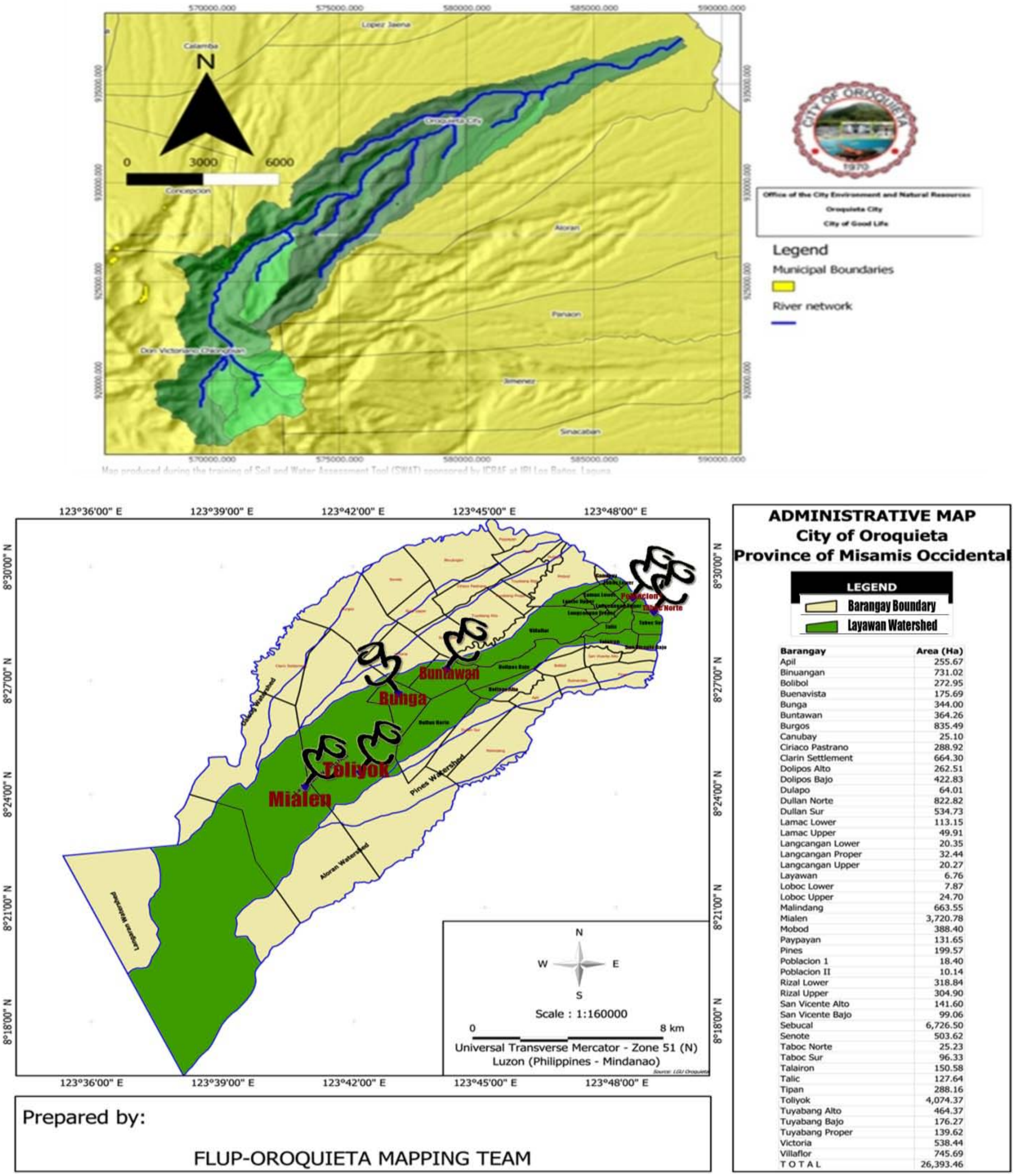
A survey questionnaire was developed to address the objectives of this study.This was administered to pre-selected individuals that represented the downstream, midstream and upstream portions of the river system.The Local Government through the Barangay Council helped in choosing these individuals based on the demographic profile of the barangay.A group discussion was initiated to focus on waste disposal, land uses and agricultural activities.

A GPS was used to geographically locate and identify the households at Layawan River system.

Results of the survey were subjected to statistical analysis using chi-square method in order to determine pollution sources that significantly affect the Layawan river.

Results and Discussion

The City of Oroquieta has a total land area of 26,393.43 hectares. It is composed of forty seven (47) barangays. Most of the barangays are traversed by Layawan Watershed. Barangay Sebucal has the biggest area of 6,640.91 hectares. This barangay also has the highest elevation of 1,106 masl. Other highly elevated barangays include Mialen and Toliyok having an elevation ranging between 500-900 masl. The lowest elevation is computed to be on the average of 10 masl that mostly constitute the urban district of the city like Barangays Poblacion II and Taboc Norte (Figure 1).



Barangay	Area (Ha)
Apil	255.67
Binuangan	731.02
Bolibol	272.95
Buenavista	175.69
Bunga	344.00
Buntawan	364.26
Burgos	835.49
Canubay	25.10
Ciriaco Pastrano	288.92
Clarin Settlement	664.30
Dolipos Alto	262.51
Dolipos Bajo	422.83
Dulapo	64.01
Dullan Norte	822.82
Dullan Sur	534.73
Lamac Lower	113.15
Lamac Upper	49.91
Langcangan Lower	20.35
Langcangan Proper	32.44
Langcangan Upper	20.27
Layawan	6.76
Loboc Lower	7.87
Loboc Upper	24.70
Malindang	663.55
Mialen	3,720.78
Mobod	388.40
Paypayan	131.65
Pines	199.57
Poblacion 1	18.40
Poblacion II	10.14
Rizal Lower	318.84
Rizal Upper	304.90
San Vicente Alto	141.60
San Vicente Bajo	99.06
Sebucal	6,726.50
Senote	503.62
Taboc Norte	25.23
Taboc Sur	96.33
Talairon	150.58
Talic	127.64
Tipan	288.16
Toliyok	4,074.37
Tuyabang Alto	464.37
Tuyabang Bajo	176.27
Tuyabang Proper	139.62
Victoria	538.44
Villaflor	745.69
TOTAL	26,393.46

Figure 1. The Layawan Watershed/River Map and the administrative map of Oroquieta City showing the study sites. (Source: *Maps produced during the training of Soil and Water Assessment Tool (SWAT) sponsored by ICRAF at IRI Los Baños, Laguna*).

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The sampled barangays in the downstream covered 0.166%, in the midstream at 2.68% and in the upstream at 29.534%.These comprised a total of 32.38% of the total area of the city of Oroquieta (Figure 2). There were a total of 270 household respondents, which were distributed into 45 household respondents per sampled barangay. This was further broken down into: upstream barangay at 35.29%, at downstream of 6.98% and at midstream of 5.67% (Table 1).

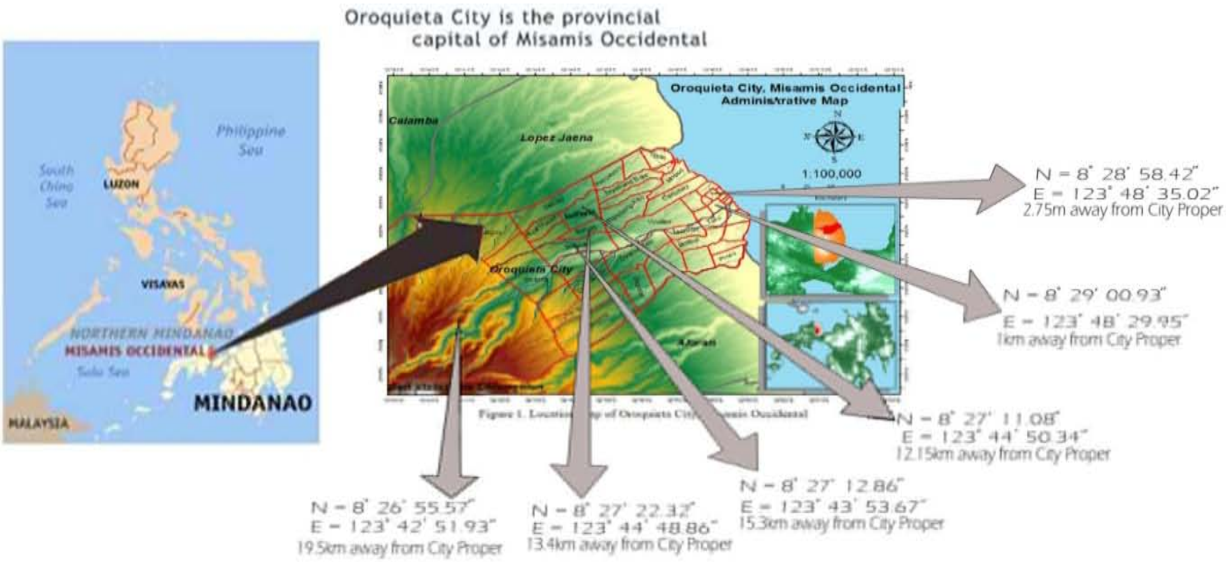

Figure 2. The geographic location of the study sites at Layawan River system, Oroquieta City.

Table1. Distance and population of each barangay with respecttoLayawan river watershed.

Barangay	Distance from town(km)	Population	No. of Households
Taboc Norte	1.0	3,363	705
Poblacion II	2.75	2,785	584
Buntawan	12.15	468	445
Bunga	13.4	1,201	1,143
Mialen	15.3	324	68
Toliyok	19.5	892	187

Socio-demographic Profile of Respondents

There were four (4) members per household (29%) and single in household structure (84%). Farming (45%) was their major livelihood, while others were engaged in fishing and quarry activities (9%).

Domestic Sources of Liquid Wastes

Majority of the respondents had their personal toilet (77%), while others had no toilet (11%). This means a potential threat of coliform contamination of the river system.

A large fraction of wastes (99%) were generated from food and utensil washings using soaps and detergents. Food washings were done three times per day using 1 regular cut (100 g) of bar detergent. Wastes were drained directly into canals, while others went into non-concreted septic tanks.

In terms of bathing and laundry activities, liquid wastes were coming from soaps and detergents used, while some used hypochlorite and fabric conditioners. On the average, respondents used 1 100g regular cut of bar detergent per laundry for three times a week. Others used 1 100g powder detergent. Upstream and midstream households were bathing and washing their clothes at the riverbanks usually three times per week.

For bathing, 1 120g bar soap was used per week, while 3-5 12mL shampoo and hair conditioners were used per week. Bathing was done in the riverbanks seven times per week. Hence, bulk of liquid wastes were directly deposited into the river system, which were roughly around 3.8 tons of bar and powder detergents, 1.5 tons of bath soaps, and 583 liters of shampoo and hair conditioners. These did not account and quantify the additives used such as skin exfoliants and conditioners, bleaching and fabric conditioners.

Agricultural Sources of Liquid Wastes

Majority of the respondents were engaged in vegetable production (45%), while others were involved in coconut and banana plantations (44%). Rice production were done in irrigated and non-irrigated farm lands. Only 8% of the farmers used synthetic pesticides in their farms without using herbicide and fungicide. Frequency of pesticide application per year was done three times. Preparation for pesticide solution was based on recommended proportions indicated in pesticide labels. Mean volume of pesticide solution used were 1-2 liters. Effluents were channeled to irrigation canal before going into the river system.

Majority of the respondents (69%) used organic sources of fertilizers such as animal manure. Its application was done twice in year for approximately 41-50kg. Fertilizer runoffs drained into open canals (upland) and in irrigation canals (lowlands) before draining into the river system.

A fraction of livestock were raised particularly chicken (38%) and swine (21%). Commercial feeds were administered. Wastes including fecal wastes, excess feeds and chemicals used (antibiotics and growth hormones) were drained into an open field and a drainage directing into the river system.

Roughly, there were 254 tons of organic fertilizers used and applied and 9721 liters of synthetic pesticides applied in farms excluding the runoffs from livestock raised.

Minor Industrial Sources of Liquid Wastes

Some respondents (42%) were involved in quarrying activities done within the riverbanks. There were 20% concessioners involved. Frequency of quarrying was done 12hrs per day at seven times a week. Eroded soils were observed thereby contributing turbidity of the river. This minor industrial activity was specifically done at midstream.

Statistical Analysis

In terms of domestic sources of liquid wastes, majority of the variables had significant (p value < 0.05) contribution of water pollution to Layawan River (Table 2). These include households without toilet, brand of soaps and detergents used, and shampoos and hair conditioners used excluding the use of fabric conditioners and bleach.

Significant (p value <0.05) contributions of liquid wastes was also observed for effluents drained from agricultural activities (Table 3). These include the types of crops and livestock raised, manner of application of feeds, pesticides and fertilizers, and the drainage system constructed.

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Table 2. Domestic sources of liquid wastes among the households draining into Layawan River system.

Variables	Df	X^2	p-value	f-value
Type of toilet	20	56.89	0.0000	31.41
Number of toilet visit	15	69.25	0.0000	24.99
Drainage of toilet	15	60.26	0.0000	24.99
Kinds of kitchen waste	15	01.68	1.00	24.99
Frequency of disposal	20	39.86	0.00	31.41
Brand of soap	45	74.07	0.00	61.63
Gram/Volume of soap	30	80.57	0.00	43.77
Kitchen drainage	15	83.71	0.00	24.99
Brand of soap	45	102.28	0.00	61.63
Gram of powder	30	29.23	0.25	37.65
Gram of bar detergent	30	46.27	0.00	37.65
Frequency of laundry	20	72.96	0.00	31.41
Chemical additives	20	59.80	0.00	31.41
Frequency of using chemical additive	25	48.78	0.00	37.65
Drainage for laundry	20	54.18	0.00	31.41
Place of bathing	15	64.32	0.00	24.99
Frequency of bathing	20	70.10	0.00	31.41
Brand of soap	50	102.55	0.00	67.50
Brand of shampoo	50	103.20	0.00	67.50
Gram soap used	25	70.04	0.00	43.77
Volume of shampoo used in sachet	25	74.01	0.00	37.65
Volume of shampoo used in bottle	25	45.21	0.00	37.65
Volume of conditioner used in sachet	25	54.29	0.00	37.65
Effluents from bathing	20	60.41	0.00	31.41

Table 3. Agricultural sources of liquid wastes draining into Layawan River system.

Variables	df	X^2	p-value	f-value
Main crops planted	35	373.51	0.00	49.76
Name of pesticide used in farms	20	113.99	0.00	31.41
Name of fungicide used in farms	15	0.00	1.00	24.99
Name of herbicide used in farms	15	0.00	1.00	24.99
Frequency of application/year	20	5.96	0.91	31.41
Manner of pesticide dosing/liter of water	5	0.82	0.84	11.07
Volume of pesticide solution used/application	20	93.96	0.00	31.41
Effluents of pesticide	20	103.85	0.00	31.41
Name of synthetic fertilizer used	20	142.39	0.00	31.41
Name of organic fertilizer used	15	27.71	0.02	24.99
Combination of synthetic/organic fertilizer	20	0.00	1.00	31.41
Frequency of application per year	20	21.85	0.34	31.41
Gram/Volume of fertilizer used	30	110.32	0.00	43.77
Effluents from fertilizer(irrigated)	15	103.85	0.00	24.99
Effluents from fertilizer(non-irrigated)	15	9.89	0.82	24.99
Small and large animals (raisers)	30	83.18	0.00	43.77
Small and large animals(population)	25	108.45	0.00	37.65
Type of housing	10	145.41	0.00	18.30

Kinds of feeds	15	65.18	0.00	24.99
Gram/volume of feeds used	30	349.47	0.00	43.77
Drainage	20	95.62	0.00	31.41

Minor quarry activities had also contributed some significant impacts (p value < 0.05) of water pollution to Layawan River, particularly on the distance of quarry site from the river system and the frequency of quarry activities. This did not account the eroded soils from farmlands and other areas.

Table 4. Minor industrial sources of liquid waste contributed by quarry activities.

Variables	Df	X^2	p-value	f-value
Distance of quarry site from river channel	25	70.72	0.00	37.65
Number of concessioners	15	0.00	1.00	24.99
Frequency of quarrying/month	20	88.42	0.00	31.41
Washings are channeled	10	4.02	0.94	18.30

Results of the study showed that anthropogenic activities thereby releasing liquid wastes can be considered as a leading cause of water quality problems. These include other agricultural and urban runoffs, improper waste disposal and faulty septic systems(Shrestha and Kazama, 2006; Brown and Froemke, 2012; Haileselasie and Teferi, 2012, as cited in Yunalyn and Nuñeza2014). The major consequences of these water pollution is a reduction of aquatic diversity (Vedra et al., 2013) and reduced economic potential of the fishes used as commercial and subsistence fishery resources (Vedra and Ocampo, 2013; Vedra and Ocampo, 2014).

Watershed areas draining the Layawan River system provide numerous ecosystem services to downstream communities often without cost to the residents. Although these services are valuable to humans, they do not have monetary values attached to them, making their total economic value quite ambiguous. This ambiguity results in the non-optimal use of the natural resources that leads to the degradation of the watersheds (Calderon et al., 2013). Watershed areas provide clean water for agricultural and domestic uses yet threats are seemingly improperly addressed (Padilla et al., 2015). The rivers are vital carriers of water and nutrients. They are critical components of the hydrologic cycle, provide habitat, nourishments and means of transportation to countless organisms. Therefore, continuing threats of water pollution must be addressed to prevent further degradation from unregulated voluminous discharges of wastewater from domestic residences, commercial properties, industry, and agricultural activities.

Conclusions and Recommendations

Bulk of liquid wastes attributed from domestic sources that were directly deposited into the river system were roughly around 3.8 tons of bar and powder detergents, 1.5 tons of bath soaps, and 583 liters of shampoo and hair conditioners excluding the chemical additives such as skin exfoliants and conditioners, bleaching and fabric conditioners. Roughly, there were 254 tons of organic fertilizers used and applied and 9721 liters of synthetic pesticides applied in farms excluding the runoffs from livestock raised. Some respondents (42%) were involved in quarrying activities done within the midstream riverbanks that, in turn, contributing turbidity of the river

Significant impacts of water pollution were observed (p value < 0.05), particularly in terms of (1) households without toilet, brand of soaps and detergents used, and shampoos and hair conditioners used excluding the use of fabric conditioners and bleach; (2) effluents drained from agricultural activities, types of crops and livestock raised, manner of application of feeds, pesticides and fertilizers, and the drainage system constructed; and (3) distance of quarry site from the river system and the frequency of quarry activities.

Generally, the residents of Oroquieta City had high awareness towards environmental and ecosystem services conservation and management. They are also aware of the adverse impacts of activities involving extraction and destruction of natural resources. Relative to this, some interventions were undertakennamely: regular coastal clean-up, mangrove planting, tree planting and information campaign on coastal resources.

This study recommends immediate information dissemination to address the issues and concerns of water pollution that might affect the status of the river system including its ecological and economic values. Additional efforts on information, education and communication (IEC) must be conducted among the residents, which can be aided by the local government and other stakeholders, primarily for the benefits of the present and future generations.

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