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Estimating Loads of Anthropogenic-sourced Pollutants into the Mandulog River System, Iligan City, Northern Mindanao

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ABSTRACT

Different concentrations, volume and quantity of liquid wastes are often neglected as part of the overall solid waste management program. As such, a descriptive study was done on the estimates of pollutants generated from domestic, agricultural and industrial activities undertaken in Mandulog River and its periphery. Interviews using survey questionnaires were conducted to 269 households representing the upstream, midstream and downstream portions of the river. Results showed an annual estimate of domestic pollutants accounted at 1.4 to 2.8 tons of detergent used in kitchen, 103 tons and 68.7 to 103 tons of powder and bar detergents, respectively, used in laundry activities, 1.8 to 3.7 tons of bath soaps, 335.7 to 504.6 L of shampoo, and 168.3 to 335.7 L of hair conditioners. In agriculture, there were 2,152 to 8,608 L of pesticide solution used, and 0.5 tons of synthetic fertilizer. Underestimated volume of eroded soils was discharged into the river system from quarry and mining activities. Given these volumes of wastes drained into the river system would mean a perception of relative water pollution problems. To this, the information shared, indigenous knowledge, attitude and perceptions of the residents gathered, in turn, have strengthened their capacity for implementing proactive means of conservation and management. This is based on their own concerted actions upon realizing the adverse impacts of pollution from their activities that could destroy their environment, their food sources and livelihood potentials.

Keywords: Anthropogenic activities, Mandulog River, water pollution.

INTRODUCTION

The level of pollution generated by various anthropogenic activities done within the river and its periphery was not thoroughly quantified. This is in particular on the liquid wastes, apart from the quantified solid waste generations. Similarly, liquid wastes are various concentrations that pose threats on the inhabiting aquatic organisms within the river system, and the overall socio-economic values of the river. Thus, this study tried to estimate the level of pollution generated from the domestic, agricultural, quarry and mining activities of the residents adjacent to the river. The socio-demographic profile of the residents like the number of household members, livelihood and other relevant attributes may also affect the quantity of wastes generated. Despite the descriptive nature of the study, this somehow depicts a picture of how simple activities can potentially affect the river ecosystem, and the inhabiting organisms. The study is founded on the concept of ecosystems interconnectivity, the dynamics of biodiversity over a period of time and space, and the prevailing socio-economic activities, that in turn, may be adversely affected by water pollution.

Water pollution generated by the residents along Mandulog River system in Iligan City, Lanao del Norte was not thoroughly quantified despite the importance of the river to their daily activities. Fishing and agriculture-related activities, quarrying of gravels and sands, and small-scale mining are occurring, and yet, the pollution contributed was not properly described, and eventually threatens the provision of basic socio-economic and ecological benefits for the present and future generations.

Mandulog river system is a home of indigenous gobies (Vedra, et al., 2013) that served both economic and ecological functions, such as their utilization for economic purposes (e.g. market of goby-fry and adult gobies) (Vedra and Ocampo, 2014). Pollution, that is more concentrated at the downstream of the river, might alter the growth and development of the returning postlarvae to the river and their morphological attributes (Vedra and Ocampo 2013; Mahilum et al. 2013). Wastes containing urine, for instance, might affect the gonadal development of the postlarvae since it contains amounts of hormones like estrogen, progesterone and testosterone. Chemicals used in laundry and agriculture might be toxic to them. Pollution might pose adverse impacts to gobies that would alter their phylogenetic and morphological descriptions, and in turn, would affect their biological and ecological values (Vedra and Ocampo, 2012). The continuing investigations on the systematics of gobies in the Philippines (UPLB Limnological Research Station. 2011) might be altered by pollution impacts like identifying a different species from a similar species due to morphological adaptations as a result of microhabitat isolation. As such, it must be addressed, but baseline estimates should be undertaken, as exemplified in this study.

MATERIALS AND METHODS

An entry protocol visit and reconnaissance surveys were done with the Barangay and Tribal Councils, the City Government office, and some residents to explain the objectives of the research, to obtain permission to conduct the study, and to ensure the community's support and cooperation in obtaining the necessary information and in assuring the availability of data from their units.

In-person interviews among the residents were conducted using a survey questionnaire, particularly on topics concerning the levels of pollution from domestic, agricultural and industrial activities. Respondents, in this context of study, refer to all the household heads or any member in the family aged 20 years and older. There were 89, 91 and 93 respondents who had represented the households located adjacent to the upstream, midstream and downstream portions of Mandulog River in Iligan City, Lanao del Norte (Figure 1). Number of respondent per household was assumed as one representative unit using the formula of Slovin (1960) as cited in Vedra (2013).

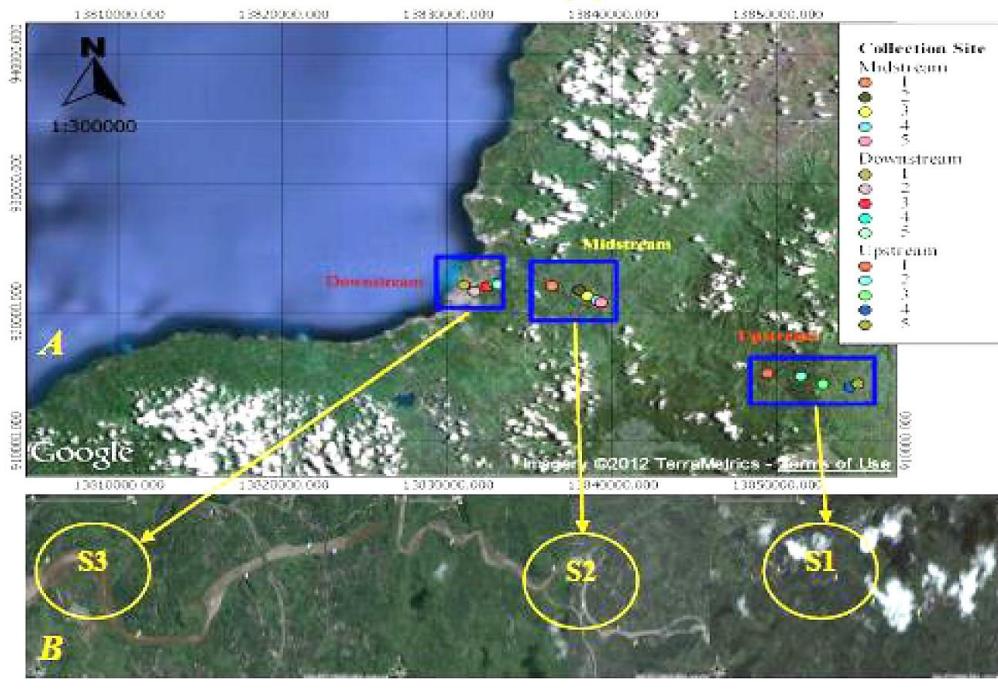

Figure 1. Google Earth generated map (A) showing the study sites in Barangays Rogongon (S1), Digkilaan (S2) and Hinaplanon (S3) representing the upstream, midstream and downstream (B) portions of Mandulog River system, Iligan City, Lanao del Norte.

RESULTS AND DISCUSSIONS

Domestic pollution sources

Toilet usage and wastes generated

Majority of the residents in midstream (74.72%) and downstream (83.87%) used water-sealed toilets, while others had antipolo-type latrines (35.95%) and others had no toilets (4.39%) (Fig. 3A). Drainage from the toilets was channelled into non-concreted septic tanks (61.53% to 79.56%), that when adverse conditions like flooding overflows, leakage from septic tanks may drain into the river system (Fig. 3B). Once (27.95% to 71.42%) and twice (28.57% to 72.04%) per day were their usual toilet usage (Figure 3C). Water-sealed toilets with concrete septic tanks would prevent spread of coliform bacteria into the river system, while the antipolo-type latrines, and if defecation was done in the riversides, coliform contamination may be of high probability.

Besides the households that have non-concreted septic tanks, the frequency of once to twice toilet usage per day, for the 4.39% households that have no toilets, might probably increase the density of coliform bacterial contamination in the water. Impacts of fecal wastes and coliform contamination to goby and other fish population were unknown. However, when these fishes were exposed to coliform contamination and were caught for consumption, health risks would be high for coliform-associated diseases like diarrhea and food poisoning. Urine discharges from toilets - which contain amounts of hormones like estrogen, progesterone and testosterone- might affect the early gonadal development of the returning postlarvae of gobies and other fishes and this may also affect their sexual attribute towards maturity. Although, this was not verified and quantified in this study, this information might help future related fishery studies.

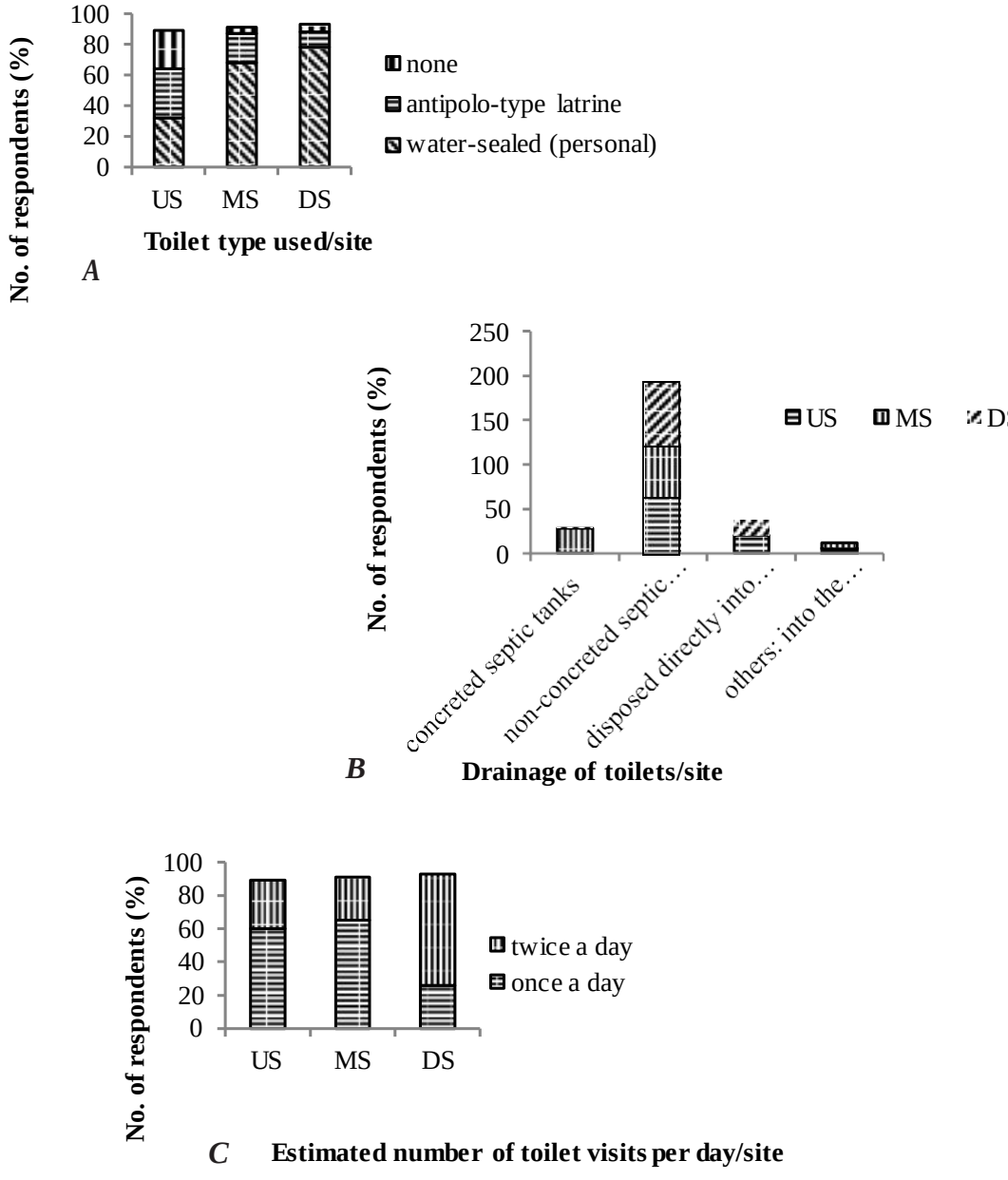

Figure 3. Types of toilet used (A), drainage of toilets (B) and estimated number of toilet visits (C) done by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

Kitchen wastes generated

Majority of kitchen wastes were composed of utensil washings (92.47% to 95.50%) containing food leftovers (74.13% to 87.64%) and detergents (62.36% to 81.31%) with some addition of sodium hypochlorite (5.37% to 59.34%). Washing of food items like meat, fish, vegetables and fruits was also prevalent, and were usually done by all residents (Fig. 4A). These kitchen washing activities were done three times (91.01% to 97.84%) per day (Fig. 4B), using one (28.08% to 79.56%) to two regular cuts (17.58% to 29.21%) of detergents per week (Fig, 4C). On the average, a regular cut of bar detergent is 100 g. Hence, this accounts an estimate of about 1.402 to 2.805 tons of detergent wastes a year used by the 269 households sampled. All these wastes are disposed directly into the non-concreted septic tanks or canals, with a range of 87.64% to 93.54% (Fig. 4D), and eventually, these canals drained into the river system with an average of 23.57 m3/sec and 27.83 m3/sec stream flow rates during dry and wet seasons, respectively. These data tried to show the relative addition of nutrients into the river

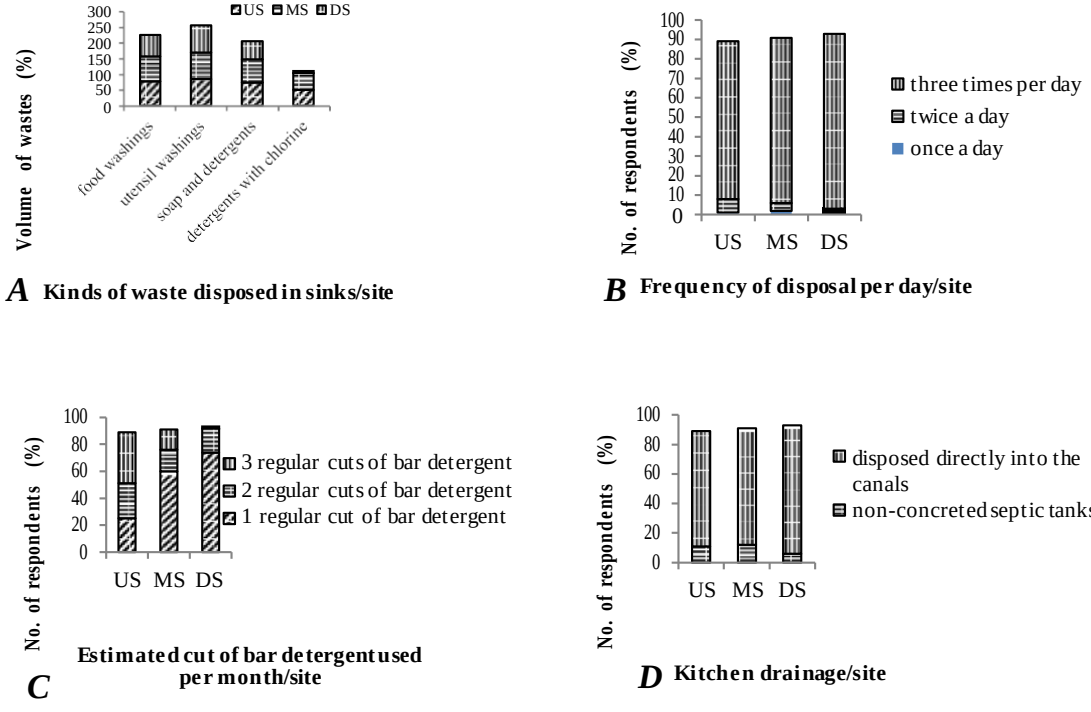

Figure 4. Kinds of wastes disposed in sinks (A) and the frequency of wastes disposal (B), estimated volume of detergent used per month (C) and kitchen drainage used by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

system by using detergents containing polyphosphate compounds and excess organic materials from food washings and kitchen wastes. This may entail favorable growths of algae and other aquatic plants, for a particular period, that in turn, might serve as sources of food for some herbivorous and omnivorous aquatic species. However, excess nutrient concentration may result to excessive algal growth, that when dead, would consume a lot of dissolved oxygen for microbial decomposition. This would jeopardize the DO requirement of the aquatic organisms.

Laundry wastes

Generally, the residents used a 300-gram sachet (30.76% to 77.52%) of powder detergent (Fig. 5A) and two (89.24% to 95.50%) to three regular cuts (4.39% to 6.45%) of bar detergents with an average of 100 g per cut (Fig 5B) for a laundry session of twice (83.51% to 91.01%) per week (Fig. 5C). This gives an estimate of 103.094 tons and 68.729 to 103.094 tons, respectively, of powder and bar detergent wastes for one year used by the 269 households sampled. This did not include the volume, of which was not accounted for, of liquid sodium hypochlorite (61.53% to 84.26%) as bleach and fabric conditioners with 6.74 % to 27.95% (Fig. 5D) used per laundry session with 83.87% to 95.50% (Fig. 5E). All laundry wastes were drained into the river system (71.42% to 81.31%) (Fig. 5F) with the average of 23.57 m3/sec and 27.83 m3/sec stream flow rates, during dry and wet seasons, respectively. Given these volumes of detergent wastes and the amounts of polyphosphates released into the river with its average stream flow rates, this might serve as the baseline information to establish, if any, the adverse impacts of detergents to aquatic population abundance and diversity.

Wastes generated from bathing

Bathing was done in the river (62.36% to 75.82%) and some did in their backyards, 24.17% to 37.63% (Fig. 6A), usually done two to three times (73.11% to 87.64%) per week (Fig. 6B). One (90.32% to 98.87%) to two (1.12% to 9.67%) regular bars of bath soaps, with an average of 135 g per bar, were used per week (Fig. 6C). Two (81.72% to 89.01%) to three (6.59% to 16.12%) regular sachets (average of 12 ml per sachet) of shampoos were used (Fig. 6D) and one (34.40% to 66.29%) to two (32.96% to 37.63%) regular sachets of hair conditioners (average of 12 ml per sachet) used per week (Fig. 6E). As such, approximately 1.888 to 3.776 tons of bath soap wastes, 335.792 to 504.670 L of shampoo, and 168.317 to 335.792 L of hair conditioners that were discharged into river (Fig. 6F), with same stream flow rates of 23.57 m3/sec and 27.83 m3/sec, respectively during dry and wet seasons, and number of 269 sampled households, as previously stated. Although, the relative volume of wastes from bath soap was relatively lower, as compared to laundry detergent wastes, but the kind of compounds contained in bath soaps may be different. Some might contain skin exfoliants, skin bleaching or whitening, anti-aging compounds, and skin moisturizers, that in turn, might be deleterious to goby and other aquatic organisms. Although this was out of the scope of study, but it may help future studies to be conducted. Shampoos and hair conditioners have compounds that enhance hair moisture, amino collagen contents and others, that in turn, might also adversely affect the goby and other fish population but were not identified in this study.

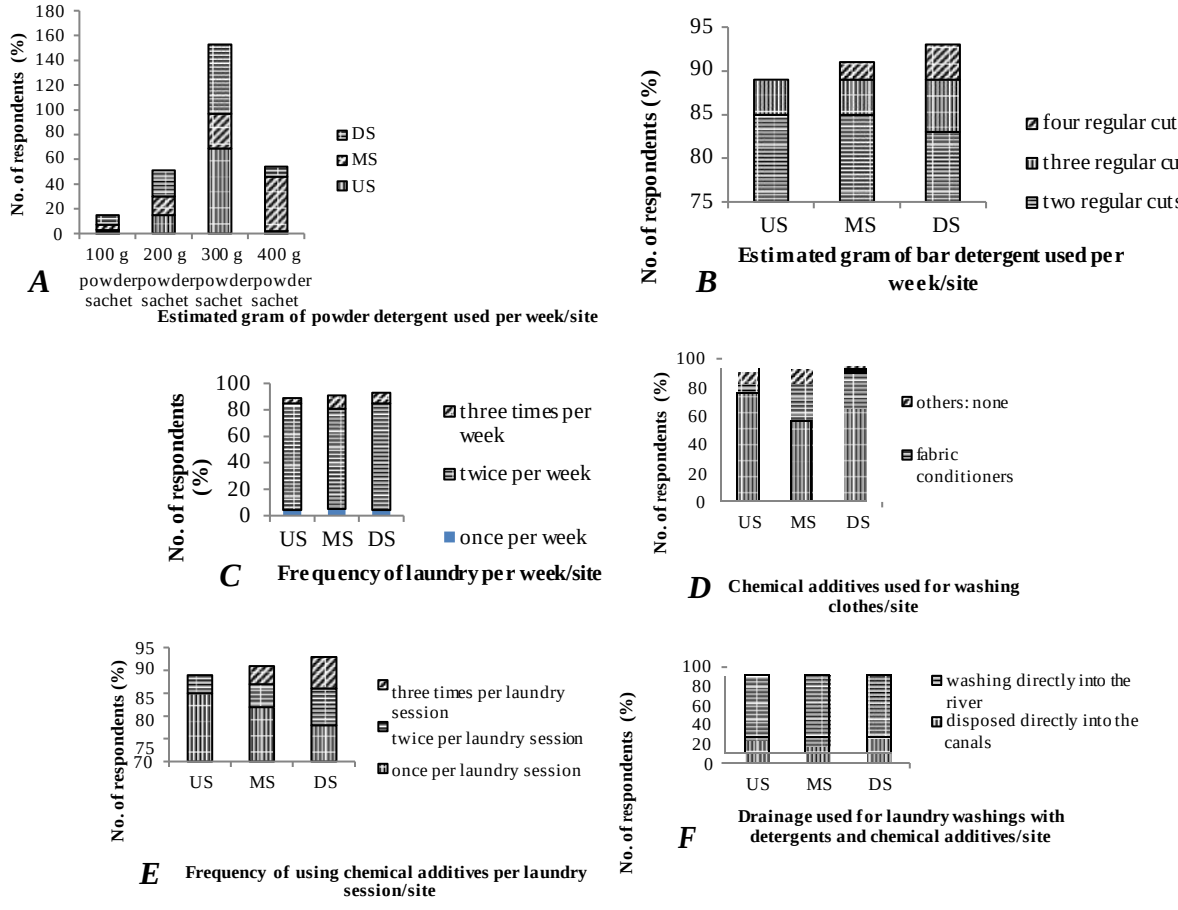

Figure 5. Estimated gram of powder detergents (A), estimated gram of bar detergents (B) and frequency of laundry per week (C), chemical additives used (D) frequency of using chemical additives per laundry session (E), and drainage used for laundry washings with detergents and chemical additives (F) used by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

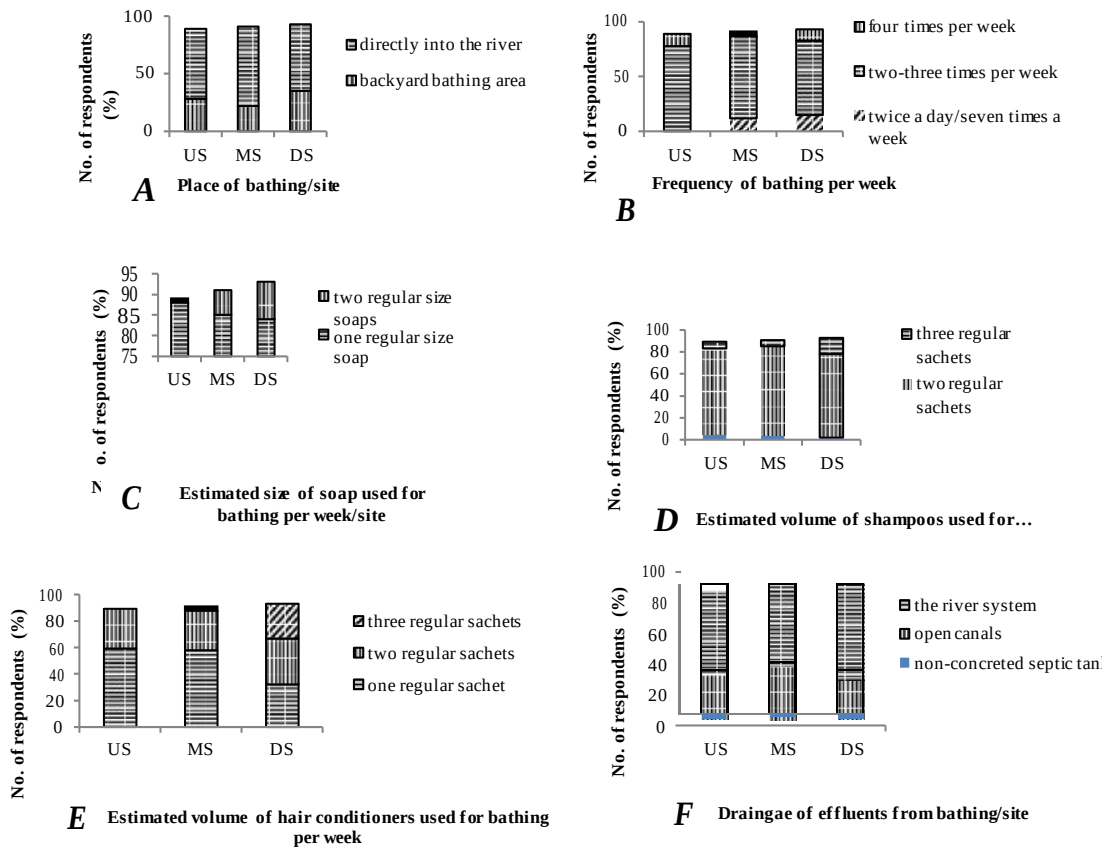

Figure 6. Place of bathing (A), frequency of bathing (B), and estimated gram of bath soap used (C) estimated volume of shampoo used (D), estimated volume of hair conditioners used (E), and effluent discharges from bathing (F) done by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

Wastes generated from agricultural activities

Majority of the crops were corn (12.90% to 97.80%), vegetables (48.31% to 68.81%), fruit trees (26.88% to 83.51%), coconut and banana (22.58% to 96.70%) (Fig. 7A), planted in a non-irrigated (100%) farmland (Fig. 7B). Among the fruit trees- particularly mangoes, pesticides and foliar fertilizers were used. These were applied two (25.84% to 71.42%) to three (8.79% to 25.80%) times per year (Fig. 7C). Pesticide dosing was based on the label (62.92% to 69.89%) while others used their own consent (28.57% to 37.07%) of pesticide formulation (Fig. 7D). One (37.07% to 45.05%) to four (54.94% to 62.32%) galloons of pesticide mixtures

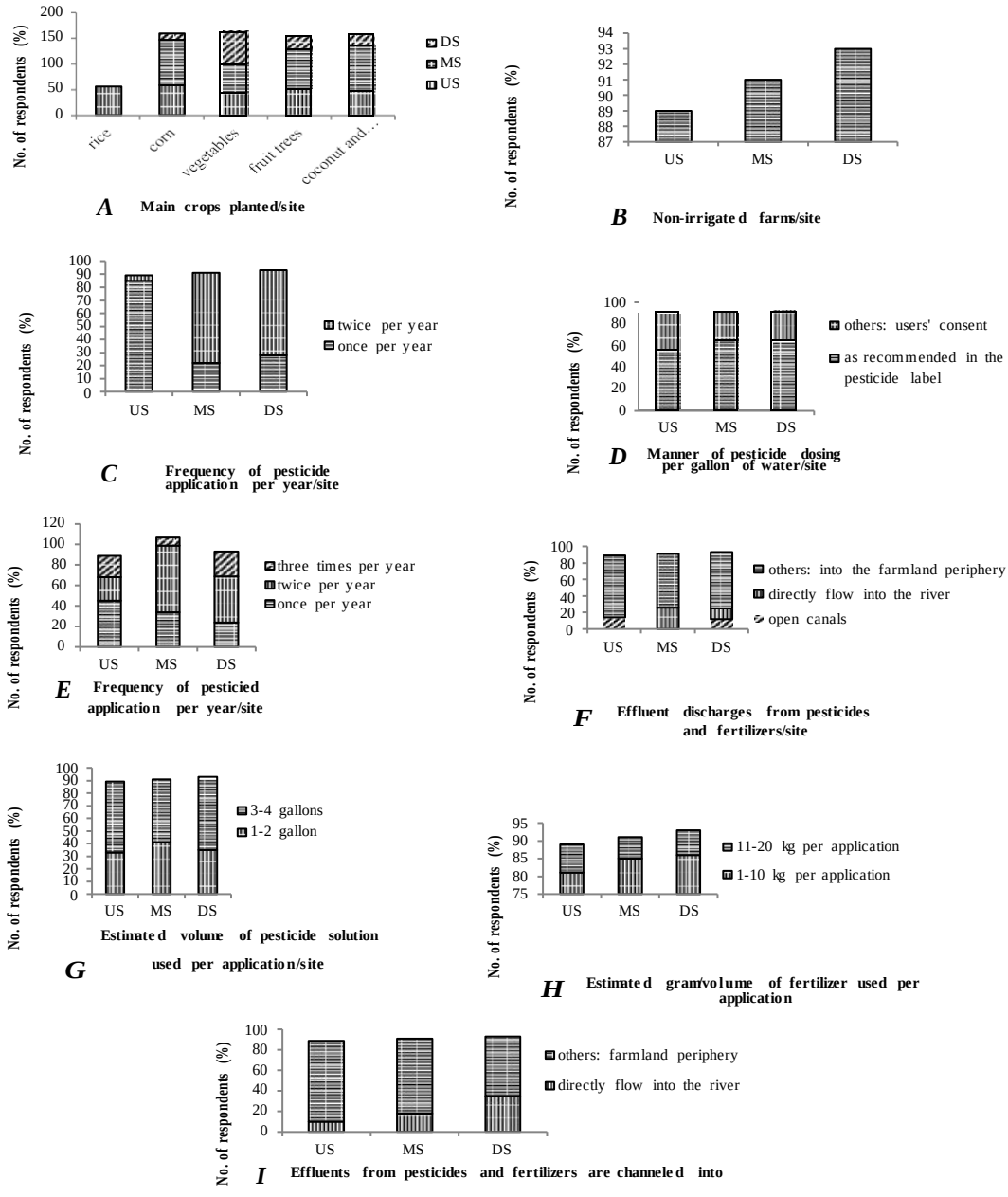

Figure 7. Main crops planted (A) in non-irrigated farms (B), and the frequency of pesticide application per year (C), manner of pesticide dosing per gallon of water per application (D), frequency of pesticide application (E) and estimated volume of pesticide solution used per application (F) estimated gram or volume of pesticide solution (G) and fertilizers (H) used per application per cropping season per year, and effluent discharges upon pesticide and fertilizer application (I) done by the residents living in the upstream (US), midstream (MS) and downstream (DS) parts of Mandulog River system, Iligan City, Lanao del Norte.

were used per application per cropping season (Fig. 7E). There are two cropping seasons per year. This may account an estimate of 2, 152 to 8, 608 L of pesticide mixtures per year for two cropping seasons, where effluents were discharged into the farmland periphery (71.42% to 84.26%) and some were leaked into the river system, 13.97% to 28.57% (Fig. 7F). Synthetic fertilizers were also used, particularly in corn plantation, while others used animal and green manure as organic fertilizers for backyard vegetable gardens. In synthetic fertilizer application, this was applied to crops one (24.17% to 95.50%) to two (4.49% to 75.82%) times per cropping season per year (Fig. 7G), with one (93.40% to 92.47%) to twenty (6.59% to 8.98%) kg of fertilizers used per application (Fig. 7H). Effluents were discharged into the river system (Fig. 7I). Approximately, this accounts an estimate of 0.538 tons of synthetic fertilizers applied per cropping season per year.

During rains, agricultural runoffs containing amounts of pesticides and fertilizers might affect the goby and other fish population. Although not quantified, pesticides are inherently toxic to them and that fertilizers might contribute nutrient loading to waters that may cause excessive algal growths besides the addition of detergent waste discharges. Excess algal growth, however, may not be favorable for the fish population as dissolved oxygen would be at stake should microbial decomposition of dead algae start.

Quarry and small-scale mining activities

Quarrying of sands and gravels were particularly done in the midstream portion of the river, within 1 to 10 meters away from the river. Frequency of quarrying per month was done 12 hours per day for seven times per week. Effluents and washings were directly discharged into the river system.

Small-scale traditional mining practices are being done in the upstream within 1 to 10 meters away from the river. Number of individuals doing mining ranged from one to 10 persons per mining session. Mining was done three to five times per year. Washings were discharged directly into the river without containing chemicals like mercury and cyanide. The known impact of quarry and mining to the abundance and distribution of freshwater gobies would be the increased water turbidity and increased total solids.

CONCLUSION

Domestic wastes and fertilizer runoffs from farms would result to additional loads of nutrients and organic matter being discharged into the river system that showed some favorable result for some herbivorous gobies and other fishes by allowing the growth of their food items. In the long run, the organic loading in the river system would potentially cause dwindling abundance of fish population, as microbial decomposition of excessive organic matter in the

water would jeopardize their DO requirement. Likewise, pesticide runoffs from farms would drastically reduce fish population through acute toxicity, especially the highly-vulnerable returning postlarvae. Eroded soils from quarry and mining activities would result to water turbidity, that in turn, might pose additional stress to fish population. Therefore, it is imperative that a regular monitoring of fish population and water quality must be done by the concerned personnel of the LGU with the help of inhabiting residents, particularly the fishers, who can give an up-to-date status of fishery to prevent overexploitation and alteration of their habitat. A simple ocular observation and fishery trends might help in this context.

The information generated in this study were mainly sourced from personal interviews and group discussions with the different cultural groups of residents who had one common understanding and knowledge that the river system was already polluted based on the unregulated anthropogenic-based activities like laundry activities, swimming, fishing, mining, agricultural practices, livestock raising and harvesting of forestal timber resources. Through this information generated, indigenous knowledge, attitude and perceptions of these residents, their awareness was strengthened by knowing that their common practices would destroy the environment like stream bank erosion, and yet they had no choice of abandoning such undertakings as these were part of their day-to-day living for survival. This in turn, helped them realized the adverse impacts of their activities that continually destroys their environment, their food sources and livelihood potentials. Lastly, this needs their urgent proactive and concerted means of conservation and management.

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LITERATURE CITED

Mahilum, J.J., J. Lalisan, C. Camama and S.A. Vedra. 2013. Morphology of Goby Species, Glossogobius celebius. (Valenciennes 1837) and Glossogobius giuris (Hamilton 1822) in Lake Lanao Mindanao, Philippines. International Journal of Research in BioSciences. 2(3): 66-78.

UPLB Limnological Research Station. 2011. Freshwater fishes in Southern Luzon. University of the Philippines Los Baños, 4031 College, Laguna, Philippines. 1-35 pp.

Vedra, S.A. 2013. Meiofauna bioindicator potentials: awareness and management options of the coastal residents of Misamis Oriental, Northern Mindanao, Philippines. International Journal of Research in BioSciences. 2(4): 47-53.

Vedra, S.A. and P.P. Ocampo. 2012. Morpho-meristic attributes and gonadal architectures of indigenous freshwater Rhinogobius goby (Herre, 1927): Implications to biodiversity and conservation potentials. List of abstracts for paper presented (oral category) during the 1st National DOST-ASTHRDP Scholar's Conference at DLSU-CSB, Manila, Philippines. 25 p.

Vedra, S.A. and P.P. Ocampo. 2013. Morphology of Rhyacichthys aspro (Valenciennes 1837) in Mandulog River system, Iligan city, Northern Mindanao, Philippines. International Journal of Research in BioSciences. 2(2): 93-105.

Vedra, S.A., P.P. Ocampo, A.V. de Lara, C.M. Rebancos, E.P. Pacardo and N.D. Briones. 2013. Indigenous goby population and conservation efforts of the communities along Mandulog River System, Iligan City, Northern Mindanao, Philippines. Journal of Environmental Science and Management. 16(2):11-18.

Vedra, S.A. and P.P Ocampo. 2014. The Fishery Potential of Freshwater Gobies in Mandulog River, Northern Mindanao, Philippines. Asian Journal of Agriculture and Development. 11(1):95-103.