Research Article

Water Quality as a Priority Area of Community Needs Assessment: Community Extension Service with the Indigenous Tribe of Hanunuo Mangyan in the Philippines

Frederick R Masangkay[1,3,*], Giovanni D Milanez[1,3], Luzelle Anne GL Ormita[2,3], Abel V Alvarez Jr.[3], Myrna P Quinto[4], Ferdianand F Lanestosa[5], Lynda Christine V Diaz[6], Paul Johnson[6], Panagiotis Karanis[7,8]

[1]Department of Medical Technology, Far Eastern University-Manila, PHILIPPINES.
[2]Department of Psychology, Far Eastern University-Manila, PHILIPPINES.
[3]Community Extension Services, Far Eastern University-Manila, PHILIPPINES.
[4]Academic Development Office, Far Eastern University-Manila, PHILIPPINES.
[5]Teacher Education Department, Divine Word College of San Jose-Occidental, Mindoro, PHILIPPINES.
[6]Research and Quality Assurance Department, Divine Word College of San Jose-Occidental, Mindoro, PHILIPPINES.
[7]University of Nicosia Medical School, Department of Basic and Clinical Sciences, Nicosia, CYPRUS.
[8]University of Cologne, Faculty of Medical and University Hospital Cologne, GERMANY.

Submission Date: 06-06-2020; Revision Date: 25-07-2020; Accepted Date: 30-08-2020

ABSTRACT

Gastrointestinal (GI) symptoms and diarrhoea are markers of intake of contaminated food and water. The present study aimed to establish water quality as a priority area in community needs assessment at the onset of Community Extension Service for indigenous communities. Dry and wet season water samples from six sampling sites were subjected to physico-chemical and microbiological analysis along with a one-year population survey (n=546) on GI symptoms and diarrhoea cases. All water sample results were non-potable based on national standards which collates with the high frequency of GI symptoms and diarrhoea in the indigenous community. Diarrhoea cases decreased after implementing a community raising-awareness program on Water Quality and Safety. The results of the present study demonstrated that water quality is a priority area in the community needs assessment of an indigenous community. Community awareness-raising programs proved effective in mitigating GI symptoms and diarrhoea through the boiling of water before consumption.

Key words: Coliform, Indigenous people, Mangyan, Philippines, Tribe, Water.

Correspondence:
Assoc. Prof. Dr. Frederick R Masangkay
[1]Department of Medical Technology, Far Eastern University Manila, 1015, PHILIPPINES.
[3]Community Extension Services, Far Eastern University-Manila, 1015, PHILIPPINES.

Phone no: +63 02 87777338
Email: frederick_masangkay2002@yahoo.com

INTRODUCTION

Studies relative to the health of indigenous people (IP) and communities are usually focused on parasitism, specifically, neglected tropical diseases like helminthiasis, fluke infections, schistosomiasis, lymphatic filariasis, leishmaniasis, malaria and intestinal protozoan infections.[1] Intestinal parasitism renders a major blow on the health and quality of life among indigenous people through malnutrition and iron deficiency[2] and is further complicated if the source of infection is from a contaminated water resource.[3] Cases of GI infections among IP which has been traced to contaminated water resources have reported *Giardia* and amoeba in Malaysia,[3] protozoa in the Amazon Region of Ecuador with a high seroprevalence of hepatitis-A and *Leptospira* spp.,[4] and *Escherichia coli* in Southern Brazil.[5] Although rich with inland freshwater resources, the Philippines have reported contamination of environmental freshwater matrices with *Cryptosporidium, Cyclospora* and

SCAN QR CODE TO VIEW ONLINE
www.ajbls.org
DOI : 10.5530/ajbls.2020.9.34

Giardia,[6-9] as well as the presence of pathogenic Free-Living-amoeba.[10-13]As part of the advocacy of the Divine Word College of San Jose, Occidental Mindoro in the preservation of culture and the enhancement of the quality of life of the Hanunuo Mangyan Tribe in partnership with the Community Extension Services (CES) of Far Eastern University-Manila, a deeper exploration of the needs assessment tool was performed. Specifically, we identified how water quality played a role in the health and quality of life of IP. The present study aimed to establish water quality as a priority area in the community needs assessment of indigenous communities by way of presenting evidence on the prevalence of GI symptoms of stomach ache and diarrhoea cases and assess the potability of water resources through physico-chemical and microbiological analysis.

METHODS

Prior informed consent was secured and awarded by the Hanunuo Mangyan Council of Elders and community members of Sitio Emok, located in Barangay Paclolo, Magsaysay, San Jose, Occidental Mindoro, Philippines before the conduct of the study which is the first program conducted at the onset of CES. A total of 546 community members from Sitio Emok Amarillo 1 (n=263) and Sitio Emok Amarillo 2 (n=283) were surveyed for Gastro-Intestinal (GI) symptoms of stomach ache/ borburygmus and diarrhea cases from March 2018 to March 2019. Key informant interviews were conducted with two members of the Council of Elders, two Sitio leaders and two Barangay Health Workers (BHWs) who were also members of the indigenous community. Dry and wet season water samples from the Ancestral Domain of the Hanunuo Mangyan of Sitio Emok were temporally assessed for potability. Six sampling sites (Figure 1) were selected for the study, namely: Cave spring (S1), Magtangkob River Basin (S2), Department of Environment and Natural Resources (DENR) water impound structure (S3), Faucet1 (S4), Faucet2 (S5) and Faucet3 (S6). Water samples amounting to 2 L per sampling site were collected in sterile plastic containers during the dry season of February to May 2019 while wet season samples were collected in August 2019. It should be noted that S3 had water derived from a spring located farther away from the community, located higher up in the surrounding hills and all faucet installations sampled were located close to households (S4 and S5) and an elementary school (S6). Water samples were maintained at 4°C during transport and sent for physico-chemical analysis and microbiological assessment by a government-accredited water testing facility within 6 hr from the time collection.

Physico-chemical analysis included 16 parameters namely: Chloride (mg/L), Chromium (mg/L), Color, (TCU), Copper (mg/L), Fluoride (mg/L), Iron (mg/L), Lead (mg/L), Manganese (mg/L), Nitrate (mg/L), Odor, pH, Sulfate (mg/L), Taste, Total Dissolved Solids (mg/L), Total Hardness (mg/L $CaCo_3$) and Turbidity (NTU) which were measured through Argentometric, Atomic absorption spectrophotometry (AAS), Visual comparison, AAS, Ion Selective, AAS, AAS, AAS, Cadmium reduction, Threshold odor, Electronic, Turbidimetric, Flavor threshold, Gravimetric, EDTA titration and nephelometric methods, respectively. The microbiological analysis included parameters of heterotrophic plate count (HPC) in CFU/mL, Total Coliform in most probable number per 100 mL (MPN/100mL) and Fecal Coliform (MPN/100mL). Water sample results were assessed based on limits set by the Philippine national standards on drinking water.[14]

RESULTS

GI symptoms and diarrhea cases

The 546 indigenous people (IP) community members surveyed for GI symptoms and diarrhoea cases from

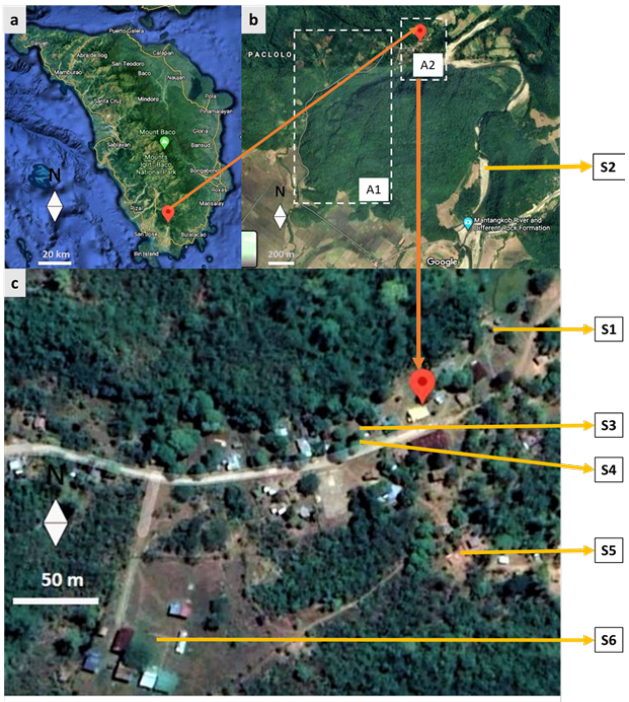

Figure 1: Geography of the indigenous community and sampling sites. a Map of Mindoro Island Philippines; b enlarged map of Barangay Paclolo, San Jose Occidental, Mindoro; A1 Sitio Emok Amarillo 1 and A2 Sitio Emok Amarillo 2; c enlarged map of A2; maps were recovered from Google maps with target location set at 12.402015, 121.193622.

March 2018 to March 2019 belonged to two sub-communities within Sitio Emok namely: Amarillo 1 (A1) and Amarillo 2 (A2) (Table 1). In Amarillo 1 (n=263), IP who experienced diarrhoea ranged from 1-79 years of age, while in Amarillo 2 (n=283), diarrhoea cases were observed from 1-71 years of age. Results show that for one year, diarrhoea cases were highest at 32% (27/84) in 0-5 years of age in A1 which was in close agreement with 39% (51/130) in 6-15 years of age in A2. The lowest cases of diarrhoea were observed from the 51-and-above age group at 11% (9/84) and 5% (5/130) for A1 and A2, respectively, with a higher number of diarrhoea cases observed in females for both sub-communities. The prevalence of diarrhoea cases within GI symptoms was observed at 32% (84/263) and 46% (130/283) for A1 and A2, respectively, with similar patterns of increase in both GI symptoms and diarrhoea cases during the wet season (June to August). Although diarrhoea cases demonstrated a consistent downward trend from September to May (going toward the dry season) (Figure 2 and 3), the cases of GI symptoms were somewhat sustained in low frequencies ranging from 6 to 62 cases per month with the highest recorded during the wet season month of June (n=62) in A1 and sustained cases of GI symptoms ranging from 6 to 76 per month with the highest case also recorded in June (n=76) in A2 (Table 1). The prevalence of diarrhoea within GI symptoms, however, revealed a different pattern for each sub-community where 47-63% was observed during October to December for A1 while

Table 1: Consolidated data of Amarillo-1 and Amarillo-2 of Sitio Emok.

Diarrhea cases														
	Sex			Age groups										Total
	M	F		0-5	6-15	16-30	31-50	51 above						
A1	40	**44**		**27**	24	15	9	9						84
A2	58	**72**		45	**51**	20	9	5						130
Diarrhea cases within GI symptoms 2018-2019														
A1	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
D	2	2	2	9	**22**	**17**	5	7	5	5	3	3	2	84
GI	11	13	6	**62**	**61**	**39**	11	15	8	10	9	10	8	263
%D	18	15	33	15	36	44	45	**47**	**63**	**50**	33	30	25	32
A2	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
D	14	4	5	**35**	**35**	**11**	8	5	3	5	2	0	3	130
GI	16	16	20	**76**	**64**	**32**	11	10	9	9	7	7	6	283
%D	**88**	25	25	46	**55**	34	**73**	50	33	**55**	29	0	50	46

A1=Amarillo-1; A2=Amarillo-2; M=Male; F=Female; D=diarrhea; GI=Gastrointestinal; %D=Prevalence of diarrhea within GI cases

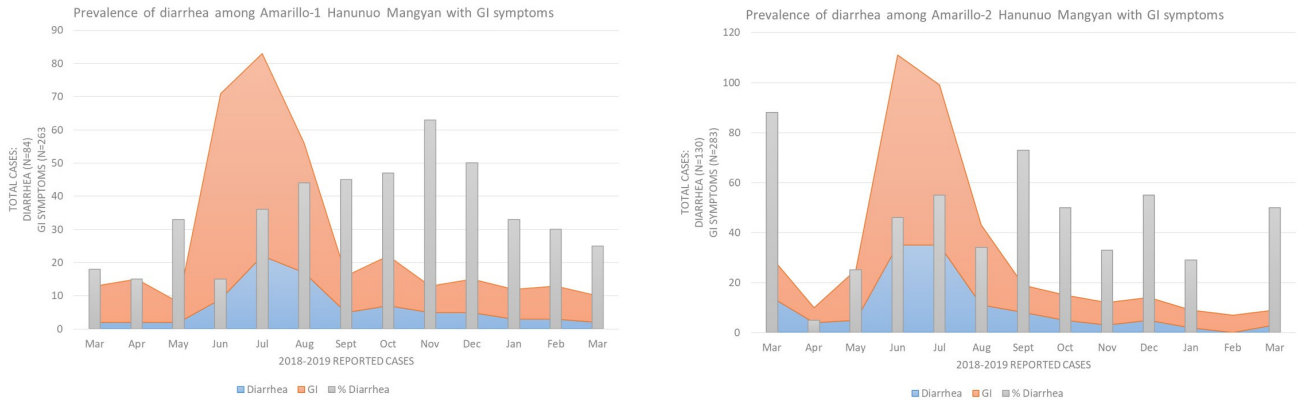

Figure 2: Graphical representation of diarrhea prevalence within GI symptoms in Amarillo 1 and Amarillo-2 of Sitio Emok from March 2018 to March 2019. Amarillo-1 demonstrated a marked increase in GI symptoms and diarrhea cases during the wet months of June, July and August while diarrhea prevalence within GI symptoms was observed during October, November and December. Amarillo 2 demonstrated higher reports of GI symptoms and diarrhea cases while showing a somewhat sporadic pattern of diarrhea prevalence observed during March 2018 to March 2019.

the highest diarrhoea prevalence within GI symptoms in A2 demonstrated a somewhat sporadic pattern with 55% in both July and December, 73% in September and 88% in March (Table 1 and Figure 2). Monthly trends of GI symptoms and diarrhoea cases were similar for both sub-communities but consistently higher in A2 compared to A1 (Figure 3). It should be noted that the sub-community area of A1 is mostly composed of farmlands (Figure 1b), the economic status, community organization and access to water resources of this sub-community is less organized. In contrast, although A2 has a smaller community area (Figure 1b), it is more organized, enjoys a higher economic standing, has easy access to water, but is densely populated with each household situated closer together (Figure 1c).

Physico-chemical and microbiological results of freshwater resources

Physico-chemical analysis of water samples (Table 2) returned with results that passed the national standards for potability with very little variations observed between the dry and wet season. However, microbiological analysis of all water samples (Table 2) from both dry and wet season returned with failed results in that heterotrophic plate counts (HPC), Total Coliforms and Fecal Coliforms registered results that exceed national standards for potability. Failed results of Heterotrophic

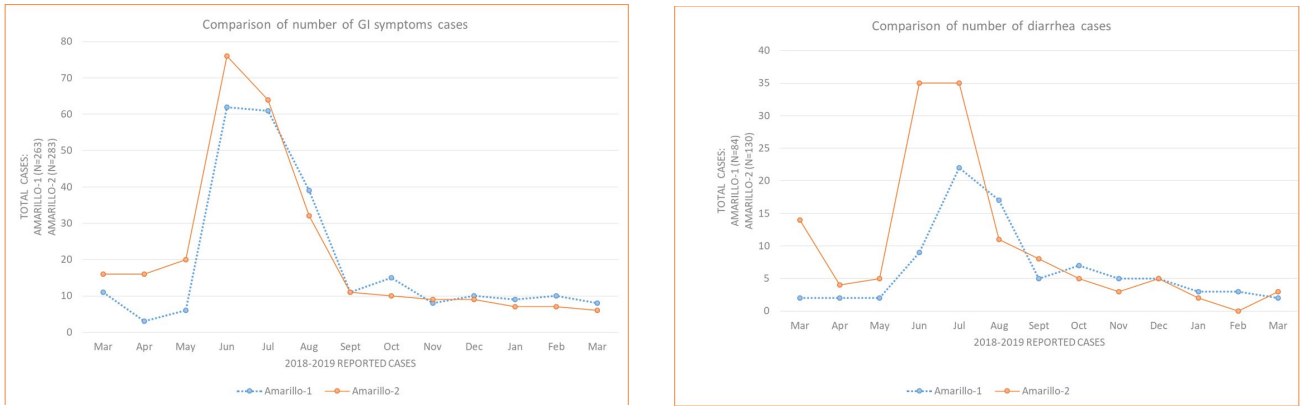

Figure 3: Graphical representation of the comparison of GI symptoms and diarrhea cases between Amarillo-1 (solid lines) and Amarillo-2 (broken lines) of Sitio Emok from March 2018 to March 2019. Data demonstrated higher reports of both GI symptoms and diarrhea cases in Amarillo-2 compared to Amarillo-1 during the wet months of June, July and August and the dry month of March 2018.

Table 2: Consolidated data on quality of water samples from Sitio Emok during dry and wet seasons.

Sampling site	Source description	Dry season sampling	Results		Wet season sampling	Results	
			Physico-chem 16 parameters	Microbiology		Physico-chem 16 parameters	Microbiology
S1	Cave spring	022819	Passed	Failed	081319	Passed	Failed
S2	Magtangkob River basin	032619	Passed	Failed	081319	Passed	Failed
S3	DENR impound tank	052019	Passed	Failed	081319	Passed	Failed
S4	Faucet closest to DENR impound tank	052019	Passed	Failed	081319	Passed	Failed
S5	Faucet farthest from DENR impound tank, elevated part of Sitio Emon	052019	Passed	Failed	081319	Passed	Failed
S6	Faucet farthest from DENR impound tank, close to elementary school	052019	Passed	Failed	081319	Passed	Failed

DENR=Department of Environment and Natural Resources; 16 parameters included Chloride (mg/L), Chromium (mg/L), Color, (TCU), Copper (mg/L), Fluoride (mg/L), Iron (mg/L), Lead (mg/L), Manganese (mg/L), Nitrate (mg/L), Odor, pH, Sulfate (mg/L), Taste, Total Dissolved Solids (mg/L), Total Hardness (mg/L $CaCo_3$) and Turbidity (NTU); Microbiology test included heterotrophic plate count (HPC) in CFU/mL, Total Coliform in most probable number per 100 mL (MPN/100mL) and Fecal Coliform (MPN/100mL).

Plate Count (HPC) in Colony-Forming Units per mL (CFU/mL) registered >6500 colonies while the most probable number per 100 mL (MPN/100 mL) of Total Coliforms and Fecal Coliforms mostly registered >8.0. Acceptable limits based on national standards for potability are at <500, <1.1 and <1.1 for HPC, Total Coliforms and Fecal Coliforms, respectively (PNSDW, 2017). The microbiological results, therefore, provided evidence of high fecal contamination of Sitio Emok's freshwater resources and the abundant presence of fecal coliforms.

DISCUSSION

The higher number of GI symptoms and diarrhoea cases, as well as the sporadically high prevalence of diarrhoea in A2 (Table 1 and Figure 2), is a peculiar finding since this sub-community is closer to the faucet installations and therefore have ready access to freshwater. Also, A2 is the more organized sub-community within Sitio Emok where cement houses and toilets are in abundance while A1 community members are more dispersed and located in farmlands near irrigation areas with small traditional bamboo and wooden houses still being the type of dwelling utilized, with no toilets available. The practice of boiling water for drinking, easier access to soap for hand washing, necessities like food, clothing and slippers, amenities like toilets and higher economic standing are more observed in A2 compared to A1. Given these stark contrasts between A1 and A2, the researchers cannot, at this time, provide any rationale why the higher incidence of GI symptoms and diarrhoea cases were observed in the more organized sub-community. Similarly, the higher cases of diarrhoea among females from both communities cannot be completely rationalized as males in both communities are more exposed to contaminated irrigation water in farmlands. It is speculated that the very intimate contact of females/mothers with their children as can be referenced from https://www.flickr.com/photos/allanbarredo/5962812311 have an unexplored role of the transmission of enteric pathogens from child to mother as the highest frequencies of GI symptoms and diarrhoea were observed in the age groups of 0-5 and 6-10 years of age in A1 and A2, respectively. In addition, the everyday chore of tending and feeding livestock like pigs and goats, as well as poultry may also play a role in this observation. Further, it is the females who frequent the community health center to have their children checked regularly by the Barangay health workers (BHW) which may have influenced the higher registry of GI symptoms and diarrhoea cases compared to the males in the community who rarely visit the community health center. These speculations, however, require a deeper and more thorough investigation.

The 16 parameters of the physico-chemical results were in close agreement for both dry and wet season samples and were all within the limits of the national standards for potability. This indicates that there were no noxious or poisonous elements in excess in the water samples.[15] Relative to this, the water samples are safe for drinking. However, the microbiological results based on national standards were all failed,[16] meaning that the water samples were contaminated with bacteria coming from human and animal excreta. In this light, the water in Sitio Emok should be subjected to chlorination or boiling before consumption to avoid morbidity or mortality due to waterborne pathogens.[17,18] In addition, it was also recommended to both communities that it is a best practice to use boiled water for washing eating utensils and drinking containers as well.

It is important to note that the water impounding structure (S3) and faucet networks (S4, S5 and S6) in Sitio Emok was only installed by the Department of Environment and Natural Resources in 2019. Although this significantly alleviated the plight of this tribal community on convenient access to freshwater, it did not provide a solution for ready access to potable water. Also, upon the conduct of key informant interviews among members of the council of elders, community members and BHWs, the community did not receive instructions on the proper chlorination of impounded water. Interviews with community members two months after the complete installation of the water impounding structure and faucets revealed a sustained case of stomach ache, borborygmus and diarrhoea among the community members. It was discovered, upon further investigation through ocular inspection, that the spring source for the water impound structure (S3) accumulated large amounts of soil and sediment. Relative to this, dredging was recommended at least twice a month. It was only after the provision of dredging instructions and implementing a community awareness-raising program on Water Quality and Safety as well as Proper hand washing did the community report a decline in GI symptoms and diarrhoea cases, possibly or mostly because of the inculcated practice of boiling water before consumption as well as using boiled water for cleaning eating utensils and drinking containers. It should be noted that this was the very first time for this IP community to receive a community awareness-raising program on Water Quality and Safety as well as Proper hand washing based on the results of the communities' freshwater resources along with instructions to perform dredging of the spring source of S3 to prevent the

accumulation of soil and sediment which may carry with it noxious substances and enteric pathogens.[19-22]It is interesting to note that the cave spring water (S1) has been an ancient freshwater resource for the indigenous community, however, it is supposed that members of the tribe to the present day have not developed any immunity following chronic exposure to the pathogens present in the water as evidenced by the high registry of GI symptoms and diarrhea cases thereby sparking interest in seroprevalence testing for waterborne pathogens.[4,23] Ingestion of water with high levels of fecal coliform contamination can potentially cause morbidity in both immunocompetent and immunocompromised individuals. More importantly, the risk of morbidity and mortality due to diarrhea is higher for children drinking fecal coliform contaminated water[24] which may be the case in the present study as the highest cases of diarrhea were reported in the age groups of 0-5 and 6-10 in sub-communities A1 and A2, respectively. This cave is inhabited by swallows, bats and frequented by legged-reptiles, snakes and frogs, the habitation of which poses an additional risk for water contamination via excreta with viruses[25-28] and waterborne protozoan pathogens like *Cryptosporidium*, *Cyclospora* and *Giardia* which are common agents of diarrhea following soil run-off due to precipitation events.[6,7,9]The results of this study, have for the first time, shed light on the quality of the freshwater resources utilized by the Hanunuo Mangyan in Sitio Emok, Occidental Mindoro, Philippines. In the perspective of CES for IP, this study has provided substantial evidence on the key role of water quality, relative to community needs assessment and may very well play a central role in building the foundations for the improvement of the health status and quality of life of IP in the Philippines. Further, community awareness-raising programs and activities have proven to be effective strategies in reducing endemic diseases,[29] which was similarly observed in the IP community engaged by the CES in the present study where the practice of boiling water before consumption aided in decreasing GI symptoms and diarrhoea cases as reported by the Council of Elders, Sitio leaders and BHWs.

The results of this study recommend the prioritization of water quality assessment in IP communities at the onset of community extension service and the implementation of community awareness-raising programs and activities towards the central role that clean water and hygiene play in the maintenance of health and improved quality of life.

CONCLUSION

The results of the present study demonstrated that assessment of water quality should be a priority area in the community needs assessment of an indigenous community, conducted at the onset of community extension service. Trends of gastrointestinal symptoms and diarrhoea cases collated with physico-chemical and microbiological results of water samples and revealed high contamination with fecal coliforms with increased gastro-intestinal symptoms and diarrhoea cases observed during the wet season. Community awareness-raising programs and activities on the quality of freshwater resources proved valuable in mitigating the effects of waterborne pathogens through the communities' adoption of the practice of boiling water before consumption.

ACKNOWLEDGEMENT

Deep gratitude is extended to the Council of Elders, Sitio Leaders, Barangay Health Workers and community members of Sitio Emok for trusting and welcoming the team for community extension service as well as for supporting the research team in the conduct of the study. This study was funded by the Community Extension Services of Far Eastern University-Manila in cooperation with the Divine Word College of San Jose-Occidental Mindoro.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests.

ABBREVIATIONS

IP: Indigenous people; **GI:** Gastro-intestinal; **CES:** Community Extension Service; **BHWs:** Barangay health workers; **DENR:** Department of environment and natural resources; **TCU:** True color units; **NTU:** Nephelometric turbidity units; **AAS:** Atomic absorption spectrophotometry; **EDTA:** Ethylenediaminetetraacetic acid; **HPC:** Heterotrophic plate count; **CFU:** Colony forming units; **MPN:** Most probable number; **PNSDW:** Philippine National Standards for Drinking Water.

REFERENCES

1. Hotez PJ, Bottazzi ME, Strych U, Chang L, Lim YAL, Goodenow MM, *et al*. Neglected tropical diseases among the Association of Southeast Asian Nations (ASEAN): Overview and update. PLoS Negl Trop Dis. 2015;9(4):e0003575. doi: 10.1371/journal.pntd.0003575.

2. Lim YAL, Romano N, Colin N, Chow SC, Smith HV. Intestinal parasitic infections among Orang Asli (Indigenous) in Malaysia: Has socioeconomic development alleviated the problem. Trop Biomed. 2009;26(2):110-22.
3. Chin YT, Lim YAL, Chong CW, The CSJ, Kok I, Yap S, *et al*. Prevalence and risk factors of intestinal parasitism among two indigenous sub-ethnic groups in Peninsular Malaysia. Infect Dis Poverty. 2016;5(1):77. doi: 10.1186/s40249-016-0168-z.
4. Romero-Sandoval N, Cifuentes L, Leon G, Lecaro P, Ortiz-Rico C, Cooper P, *et al*. High rates of exposures to waterborne pathogens in indigenous communities in the Amazon region of Ecuador. Am J Trop Med Hyg. 2019;101(1):45-50. doi: 10.4269/ajtmh.18-0970.
5. Balan DS, Piva JC, Falavigna-Guilherme AL, Rossoni DF, DeOrnelas TMJ. Spatial distribution and enteroparasite contamination in peridomiciliar soil and water in the Apucaraninha Indigenous Land, Southern Brazil. Environ Monit Assess. 2016;188(4):217. doi: 10.1007/s10661-016-5216-4.
6. Masangkay F, Milanez G, Chua N, Angulo F, Aquino P, Calucin D, *et al.* Waterborne coccidians in Philippine water sheds: A national inceptive study. Asian J Biol Life Sci. 2016;5(2):112-9.
7. Masangkay F. Increased detection of Cryptosporidium and *Cyclospora* spp. oocysts in a major Philippine watershed following rainfall events. Asian J Biol Life Sci. 2019;8(3):111-6. doi:10.5530/ajbls.2019.8.18.
8. Masangkay, F.R., Milanez, G.D., Tsiami, A., Somsak, V., Kotepui, M., Tangpong, J., Karanis, P., 2020a. First report of Cryptosporidium hominis in a freshwater sponge. Sci Total Environ. 700:134447. doi: 10.1016/j.scitotenv.2019.134447.
9. Masangkay FR, Milanez GD, Tsiami A, Hapan FZ, Somsak V, Kotepui M, *et al*. Waterborne protozoan pathogens in environmental aquatic biofilms: Implications for water quality assessment strategies. Environ Pollut. 2020b;259:113903. doi: 10.1016/j.envpol.2019.113903.
10. Milanez GD, Masangkay FR, Thomas RC, Ordona MOGO, Bernales GQ, Corpuz VCM, *et al*. Molecular identification of *Vermamoeba vermiformis* from freshwater fish in lake Taal, Philippines. Exp Parasitol. 2017;183:201-6. doi: 10.1016/j.exppara.2017.09.009.
11. Milanez G, Masangkay F, Somsak V, Kotepui M, Karanis P. Occurrence and first report of *Naegleria australiensis* presense in a major Lake in the Philippines. J Wat Health. 2019;17(4):647-53.
12. Milanez G, Masangkay F, Hapan F, Bencito T, Lopez M, Soriano J, *et al*. Detection of *Acanthamoeba* spp. in two major water reservoirs in the Philippines. J Water Health. 2020;18(2):118-26. doi: 10.2166/wh.2020.190.
13. Hagosojos B, Masangkay F, Fernandez JB, Lazaro JA, Medroso DE, Olaguera B, *et al*. Molecular identification of *Acanthamoeba* sp. in lake Buhi, Philippines. Ann Parasitol. 2020;66(1):111-4. doi: 10.17420/ap6601.245.
14. DOH (Department of Health) administrative Order # 2006-0024, Rules and regulations governing the accreditation of laboratories for drinking water analysis. Republic of the Philippines, Department of Health Office of the Secretary Manila. 2006.
15. PNSDW (Philippine National Standards on Drinking Water). Administrative order No. 2007-0012. Republic of the Philippines, Department of Health, Office of the Secretary. 2007.
16. PNSDW (Philippine National Standards on Drinking Water). Administrative Order No. 2017-0010. Republic of the Philippines, Department of Health, Office of the Secretary. 2017.
17. Ribeiro MR, Carlos DAL, Laporta GZ. Drinking water and rural schools in the Western Amazon: An environmental intervention study. Peer J. 2018;6:e4993. doi: 10.7717/peerj.4993.
18. Sudsandee S, Fakkaew K, Kaewdounglek V, Laor P, Worakhunpiset S, Apidechkul T. Drinking water investigation of hill tribes: A case study in Northern Thailand. Int J Environ Res Public Health. 2020;17(5):1698. doi: 10.3390/ijerph17051698.
19. DaSilva JB, Piva C, Falavigna-Guilherme AL, Rossoni DF, DeOrnelas TMJ. Spatial distribution and enteroparasite contamination in peridomiciliar soil and water in the Apucaraninha Indigenous Land, Southern Brazil. Environ Monit Assess. 2016;188(4):217. doi: 10.1007/s10661-016-5216-4.
20. Dwivedi AP, Tripathi IP, Suresh KM. Assessment of soil and ground water quality in Rewa District of Vindhyan Plateau (India). J Environ Sci Eng. 2013;55(1):51-64.
21. Fuhrimann S, Stalder M, Winkler MS, Niwagaba CB, Babu M, Masaba G, *et al.* Microbial and chemical contamination of water, sediment and soil in the Nakivubo wetland area in Kampala, Uganda. Environ Monit Assess. 2015;187(7):475. doi: 10.1007/s10661-015-4689-x.
22. Poma V, Mamani N, Iñiguez V. Impact of urban contamination of the La Paz River basin on thermotolerant coliform density and occurrence of multiple antibiotic resistant enteric pathogens in river water, irrigated soil and fresh vegetables. Springer Plus. 2016);5:499. doi: 10.1186/s40064-016-2132-6.
23. Pumann P, Kožíšek F, Craun GF, Kunde TR, Malý M, Frost FJ, *et al*. High serological response to Cryptosporidium-specific antigens in the Czech Republic and its association with water supply. J Wat Health. 2019;17(5):691-700. doi: 10.2166/wh.2019.061.
24. Moe CL, Sobsey MD, Samsa GP, Mesolo V. Bacterial indicator of risk of diarrhoeal disease from drinking water in the Philippines. Bull World Health Organ. 1991;69(3):305-17.
25. Banyai K, Kemenesi G, Budinski I, Foldes F, Zana B, Marton S, *et al*. Candidate new rotavirus species in Schreiber's Bats, Serbia. Infect Genet Evol. 2017;48:19-26. doi: 10.1016/j.meegid.2016.12.002.
26. Holz PH, Lumsden LF, Druce J, Legione RA, Vaz P, Devlin JM, *et al*. Virus survey in populations of two subspecies of bent-winged bats (Miniopterus Orianae Bassanii and Oceanensis) in South-Eastern Australia reveals a high prevalence of diverse herpes viruses. PLoS One. 2018;13(5):e0197625. doi: 10.1371/journal.pone.0197625.
27. Khuroo MS, Khuroo MS, Khuroo NS. Hepatitis E: Discovery, global impact, control and cure. World J Gastroenterol. 2016;22(31):7030-45.
28. Yinda CK, Ghogomu SM, Conceicao-Neto N, Beller L, Deboutte W, Vanhulle E, *et al*. Cameroonian fruit bats harbor divergent viruses, including rotavirus H, bastroviruses and picobirnaviruses using an alternative genetic code. Virus Evol. 2018;4(1):vey008. doi: 10.1093/ve/vey008.
29. Matsumoto-Takashi ELA, Tongol-Rivera P, Villacorte EA, Angluben RU, Yasuoka J, Kano S, Jimba M. Determining the impact of community awareness-raising activities on the prevention of Malaria transmission in Palawan, the Philippines. Parasitol Int. 2014;63(3):519-26. doi: 10.1016/j.parint.2014.01.008.

Cite this article: Masangkay FR, Milanez GD, Ormita LAGL, Alvarez AV, Quinto MP, Lanestosa FF, et al. Water Quality as a Priority Area of Community Needs Assessment: Community Extension Service with the Indigenous Tribe of Hanunuo Mangyan in the Philippines. Asian J Biol Life Sci. 2020;9(2):220-6.