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Microbial Assessment of Davao Oriental State College of Science and Technology's (DOSCST) Water System Mati, Davao Oriental: A Basis for Management Intervention

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Abstract

This study dealt with the microbial assessment of the water system of Davao Oriental State College of Science and Technology (DOSCST). It determined the Most Probable Number (MPN) of coliforms, identifying the genera of coliforms, water consumption, and health-related information among the students, faculty, staff, and management intervention to water supply. The study was conducted in the DOSCST's main campus. Collection of water samples was done on December 2006 and January 2007 Results disclosed that the Most Probable Number (MPN) of coliforms in the water sample ranged from 9, 11, 13, and 16. Thermotolerant bacteria, Escherichia coli, Pseudomonas aeruginosa, and Klebsiella pneumonia were the four (4) genera of coliforms found in the water samples. Thus, water proved to be not suitable for drinking. Evidently, the students (50.70%), faculty (49.98%), and staff (43.33%) consumed the water supply of the college for drinking, washing, cooking, bathing, and watering of plants. The frequency of usage was seldom for students, frequent for the faculty, and most frequent for the staff. Of all the respondents, students (0.3%) and faculty (0.7%) had experienced water-related health problems such as stomach aches and skin rashes. Students had experienced water-related health problems most frequently, while the faculty had experienced them always. On the other hand, the staff had never experienced any water-related health problems.

Keywords: Bacteria, Coliforms, *Klebsiella, Pseudomonas*, Thermotolerant

Introduction

The water supply of the DOSCST is obtained from a 54-meter deep well (DOSCST Engineering Office, personal communication, 2006) poured to the steel tank located at Menzi, Mati, Davao Oriental. It is piped through the concrete tank inside the Campus that distributes water supply to the faucets of every building. Water supply is used for drinking, washing, bathing, cooking and watering of plants. Water is one of our most important natural resources. There would be no life on earth without it. The lifestyles we have become accustomed to depend heavily upon having plenty of cheap, clean water available as well as inexpensive, safe way to dispose it after use.

The availability of the supply of water for use is by nature, limited. Although on earth there is plenty of water, it is not always in the right place, in the right time and of the right quality (Sorell, 2006). The quality of water which is set up by relevant authorities in various countries or international agencies such as World Health Organization (WHO) or European Community is measured by its physical, chemical, radiological and biological limits (Adam et al. 1989). Both assessment and identification of conditions that can lead to the growth of microbes are important because of the potential health effects caused by certain bacteria and fungi (Howe, 2006). Water, sanitation and hygiene have important impacts on both health and diseases. Water-related diseases may include those due to microorganisms and chemicals that people take, diseases like schistosomiasis, which has part of their lifecycle in water, malaria with water-related vectors, and others such as legionellosis carried by aerosols containing microorganisms (http://www.who.int.). Microbial contamination of water has long been a concern of the public. From 1920's to 1960's, the bacillus that causes typhoid fever was considered a major problem in the water supply. Once it was eradicated, new microbes are present to take its place (Keyser, 1997).

The majority of water-borne microorganisms that caused human disease come from animal and human fecal wastes. These wastes contain a wide variety of viruses, bacteria and protozoa which may get washed into the drinking water supply (http://www.microbeworld.org.). The group of coliform bacteria consists of several genera belonging to the Family Enterobacteriaceae. Mostly, these harmless bacteria live in soil, water and the digestive system of animals including humans. Belonging to this group, fecal coliform bacteria are present in large numbers in the feces and digestive tracts of animals and other warm-blooded animals and from human and animal waste that can enter the water bodies. If a large number of fecal coliform bacteria (over 200 colonies/milliliters of water sample) are found in the water, pathogenic organisms are possibly present in the water fecal coliforms are not pathogenic. In fact, they are indicator o rganisms in which they may indicate the presence of other pathogenic bacteria (Murphy, 2006).

This study dealt with the microbial assessment of the water system of Davao Oriental State College of Science and Technology (DOSCST). It determined the Most Probable Number (MPN) of coliforms, identifying the genera of coliforms, water consumption, and health related information among the students, faculty and staff, and the management intervention to DOSCST's water supply.

Methodology

Study area

The study was conducted in DOSCST Campus which is located in Guang-guang, Dahican, Mati, Davao Oriental. The sampling stations were selected eight faucets in the college located in administration building, canteen, Natural Sciences Department (NSD), Engineering and Technology Department (ETD) Shop, Business and Rural Development Department (BARDD), Piggery, Research and Extension (R&E), and Library of which in one way or another, students, faculty and staff sourced water. One faucet was sampled in each station. Water sampling was done on December 28, 2006 and January 9, 2007. The schedule followed that of the schedule given by the Davao City Water District (DCWD) personnel as to their availability to analyze the samples. The collection was done at 7-8 in the morning. Water samples of each station had an approximate volume of 200ml of water placed in sterilized bottle and was immediately brought to Davao City Water District for microbial analysis.

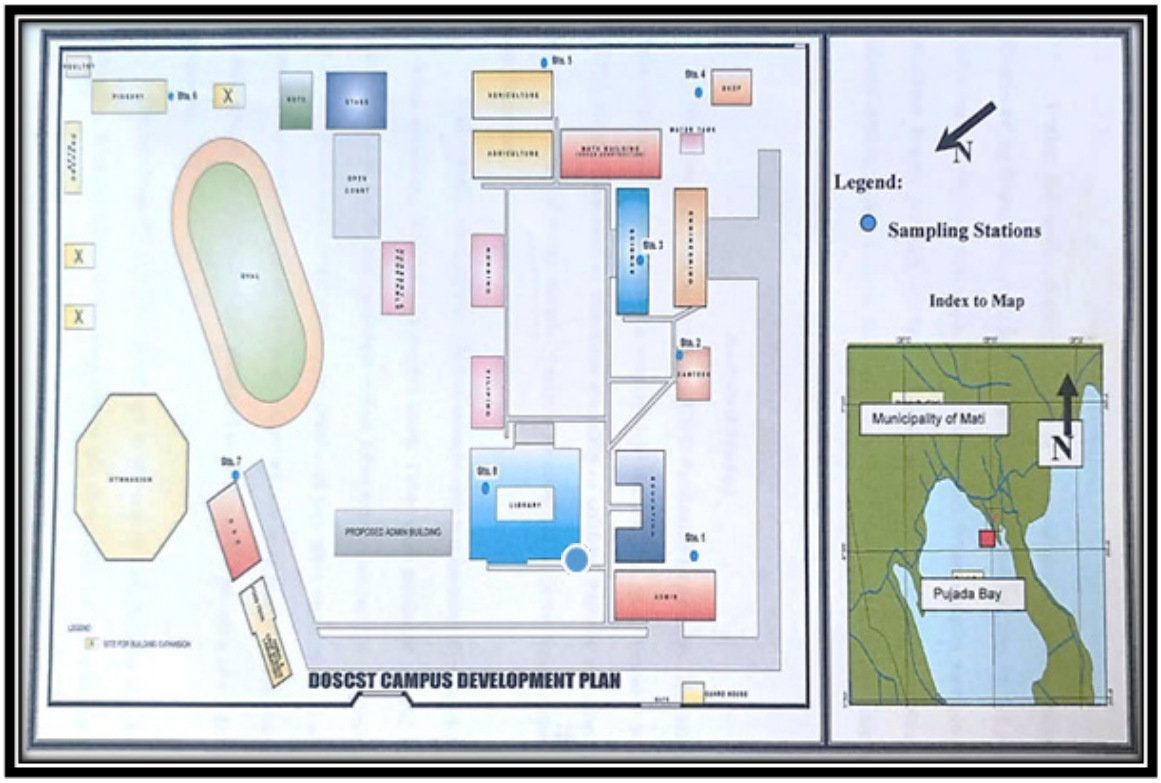

Figure 1. Map of the DOSCST campus development plan where sampling stations (●) are shown.

Sampling technique

During the water sampling, mouth or edges of faucets were sterilized and disinfected by heating and applying a 70% isopropyl alcohol solution for 2-3 minutes following the water to run to waste 2-3 minutes as well. Water samples were placed in a sterilized bottles provided by the DCWD production department. The bottles were labeled with the name of station for identification and were placed in an ice cooler during the maximum transport time.

Analytical method

Water samples were analyzed at DCWD production department. The Multiple-Tube Fermentation Technique was employed in the analysis. Most Probable Number (MPN) method was used to determine the MPN of coliform bacteria and identify its genera per 50ml of water sample. Analysis involved presumptive, confirmatory and completed test. With a sterile 10ml pipette, 10ml of water sample was inoculated into each of five tubes containing 20ml of presumptive broth. Tubes were incubated at 37°C for 24 hrs. At the end of 24-hr incubation period, tubes were examined for the presence of gas in the Durham tube. Effervescence or streams of tiny tubes were observed and the tubes were considered positive. However, negative tubes were reincubated further for a 24-hr period. Gas production was presumed to be due to the presence of coliforms in the sample. The confirmatory test was carried out at the end of both 24-hr and 48-hr incubation. With the use of sterile loop, one or two drops from each presumptive tube was transferred into *Escherichia coli* (EC) medium broth and Brilliant Green Lactose Bile (BGLB) broth and incubated for 24 hrs at 37°C. The BGL.B from each presumptive positive tube was incubated to confirm the presence of total coliforms. On the other hand, negative tubes were reincubated and gas production at the end of

24-hr and 48-hr incubation was confirmed on presence of coliforms in the sample. However, thermotolerant coliform was confirmed at the end of 24-hour with the incubated EC tubes from each presumptive positive tube at 44 x 0.5°C. The completed test was performed using MacConkey agar to identify the genera of coliforms present.

Statistical analysis

Data was analyzed using descriptive statistics wherein frequency counts, means and percentages were categorized and tabulated. A t-test was used in the study in comparing the standard drinking water and the water of DOSCST

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)s^2 + (n_1 - 1)s^2 2}{n_1 + n_2 - 2}\left(\frac{n_1 + n_2}{n_1 n_2}\right)}}$$

Where: $\underline{X}_1$ is the mean for 1st sampling = 16

$\underline{X}_2$ is the mean for 2nd sampling = 9.34
$\underline{n}_1$ is the number of samples in 1st sampling = 8
n_2 is the number of samples in 2nd sampling = 8
s_1 is the variance for 1ª sampling = 0
s_2 is the variance for 2nd sampling = 34

Data collection

Both primary and secondary data were gathered to coincide the objectives of the study. Water samples were gathered on December 2006 and January 2007 at 7-8 in the morning. Some of the data were obtained through the responses of the students, faculty and staff on the questionnaire used as one of the research instruments of the study. Actual interview with the in-charge personnel of DOSCST's water system regarding sanitary practices was done. Data from Mati Water District and private and public hospitals were consolidated. Secondary data were gathered from textbooks, journals and the internet.

Respondents of the study

Students, faculty and staff of the college were among the respondents of the study and who were the consumers of the water supply. List of students were obtained from the registrar's office while the list of faculty and staff were taken from the Human Resource and Management Office (HRMO). Cluster sampling technique was employed in the study. A sample size of 320 students, 58 faculty and 45 staff were identified as the total number of respondents. Sample size was determined using the Slovin's formula.

$$n = \frac{N}{1+N\,(e)2}$$

Where:
N - population size
n - sample size
e - allowable error (5%)

Research instruments

The study established a semi-structured questionnaire in conducting the survey on consumers' satisfaction on the water quality of DOSCST's water system. Sterilized bottles were used as containers of the water samples.

Results and Discussion

Most Probable Number (MPN) of Coliforms

Table 1 shows the Most Probable Number (MPN) of coliforms in each station. The MPN ranged from 16 down to 2.2. Three stations had the highest yet constant MPN from the first and second sampling. These were Stations 4 (Engineering and Technology Department (ETD) Shop), Station 5 (Business and Rural Development Department (BARDD), and Station 6 (Piggery) which has 16 MPN. Apparently, one of these faucets (piggery) had a pig stock beside it which would possibly be the source of contamination by feces of the stock. Moreover, the other faucet attached to it was once leaked which attributed to the entrance of microbes into the faucet. Station 7 (Research and Extension (R&E) had high MPN second to the first which was 13. This station was attached to the pipe of the 3 stations (Administration building, Canteen and NSD) which had 11 MPN lower than station 7. The least MPN was found in Station 8 (library) which was 9.

Table 1. Most Probable Number (MPN) of water sample.

STATION	Most Probable Number		TOTAL	MEAN	SD
	Sampling(1)	*Sampling(2)*			
Admin. Bldg.	16.00	5.10	21.10	11	8.17
Canteen	16.00	5.10	21.10.	11	8.17
NSD	16.00	5.10	21.10	11	8.17
ETD Shop	16.00	16.00	32.00	16	1.63
BARDD	16.00	16.00	32.00	16	1.63
Piggery	16.00	16.00	32.00	16	1.63
R&E	16.00	9.20	25.20	13	5.38
Library	16.00	2.20	18.20	9	5.30

The Most Probable Number (MPN) of coliforms in water samples indicated the water is not suitable for drinking considering that the MPN was beyond the normal limits of less than 2.2/100ml water sampled. There was a high significant difference between the standard drinking water and the DOSCST water samples based on the 1-Test analysis as shown in Table 2. Using the t-tabulated value at 0.01 levels, it showed a higher calculated value (3.23) than tabulated value (2.62). Hence the water samples coming from DOSCST faucet have greater reading than the standard potable water It implies that the water from the tank of DOSCST's water system is not potable.

Table 2. A t-test analysis between MPN of standard drinking water and MPN of DOSCST water samples.

MPN	Mean	SD	Normal	t-calculated	t-tabulated		Remarks
					0.05	0.01	
203	12.67	5.01	2.2	3.23	1.761	2.624	Highly significant

Genera of coliforms

There were 4 genera of coliforms identified in the water samples taken from first and second sampling of the 8 sampling stations (Table 3). In Stations 1 (Admin Bldg.), 2 (Canteen), 4 (ETD Shop), 6 (Piggery) and 7 (R&E), Thermotolerant bacteria, *Escherichia coli, Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were all present. In Stations (NSD) and 8 (Library), 3 genera were found, Thermotolerant, *K. pneumoniae and P aeruginosa* while the E. coli was absent. However, there was no *P. aeruginosa* found in Station 5 (BARDD). The presence of Thermotolerant bacteria in all sampling stations may be due to its ability to grow at elevated body temperature which is 44.5°C (http://www.nio.org). Considering that *Escherichia coli* is single-celled organisms, its presence and absence in sampling stations might be due to its respond to environmental signals such as the chemicals used during the sampling. It can sense the presence or absence of chemicals and gases and swim towards or away from them. It can also stop swimming and grow in fimbriae that will specifically attach to a cell or surface receptor (Todar 2002). However, the presence of *Klebsiella pneumoniae* in the water samples of every station might be due to its characteristic as a non-motile genus (http: www/sunysecc.edu). Probably during the sampling, it was steadily present in the stations as it did not disappear from the water samples. Possibly, the presence of *Pseudomonas aeruginosa* and its absence in station 5 (BARDD) may be due to the fact that it is motile by means of single polar flagellum and it can live in sessile biofilm form or a planktonic form as a free-swimming cell (http:www.tjelarkine.com).

Table 3. Genera of coliforms found in the water samples.

STATIONS	ISOLATED ORGANISM	
	First sampling	Second sampling
Admin. Bldg.	Thermotolerant bacteria. *Escherichia coli, Klebsiella pneumoniae*	*Pseudomonas aeruginosa,* Thermotolerant bacteria, *E. Coli*
Canteen	Thermotolerant bacteria, *K. pneumoniae*	Thermotolerant bacteria, E.*coli, Pseudomonas aeruginosa, K. pneumoniae*
NSD	Thermotolerant bacteria, *K. pneumonaie*	*P. aeruginosa, K. pneumoniae*
ETD Shop	Thermotolerant bacteria, *E.coli, K. pneumoniae*	*P. aeruginosa,* Thermotolerant bacteria, *E.coli*
BARDD	*K. pneumoniae,* Thermotolerant *bacteria, E.coli*	Thermotolerant bacteria, *E.coli*
Piggery	Thermotolerant bacteria, *K. pneumoniae*	*P. aeruginosa,* Thermotolerant bacteria, *E.coli*
R&E	*K. pneumoniae,* Thermotolerant bacteria, *E.coli*	*P. aeruginosa,* Thermotolerant bacteria, *E.coli*
Library	Thermotolerant bacteria, *K pneumoniae*	*P. aeruginosa*

Accordingly, if any coliform bacteria are present in the water sample, infectious pathogens are assured to be present as well. The Environmental Protection Agency (EPA) considers water with any coliform bacteria to be unsafe for drinking (Cunningham et al 2006).

Furthermore, World Health Organization (WHO) recommends that drinking water should be free from coliform bacteria (Rangsayatorn, 2006).

Water consumption

The total respondents of the study were 423, composed of 320 students, 58 faculty members and 45 staff members of the college who were the consumers of the water supply. Table 4 shows how the respondents consumed the DOSCST's water supply It shows that for drinking, both students (94%) and staff (51%) most frequently used the water while frequently were the staff (76%). For washing 100% of the respondents had used the water The students (8%) always used water for cooking whereas faculty (9%) frequently used. However the most frequent used of water for cooking was the staff (7%). For bathing, (2%) of students seldom used the water, frequent were the faculty (3%) while the most frequent were the staff (15%). As shown in Table 5, frequency distribution on water and health related information; both students and faculty had experienced water-related health problems such as stomach disorder and skin rashes, though there were slight differences of the frequency. From the table below, few students (0.3%) had experienced such disorders while the faculty (0.7%). However, 100% of the staff had not experienced any water-related health problems at all. The possible reason was that most of the staff did not drink water as much as students and faculty did. They preferred distilled drinking water" and "soft drinks" rather than the DOSCST's water supply.

Table 5. Frequency distribution on water and health related information.

	YES		**NO**		**TOTAL**	
	n	%	n	%	n	%
STUDENTS	1	0.3	318.6	99.6	320	100
FACULTY	0.4	0.7	57.6	99.3	58	100
STAFF	0	0	45	100	45	100
TOTAL	1.8	1.3375	421.2	298.9	423	300

Table 6 shows how often respondents experienced water-related health problems. It shows that most frequently (2.4), students had experienced water-related health problems from utilizing the water supply. The faculty had always (1.6) experienced so, while the staff had not experienced any disorders at all.

Table 4. Frequency distribution on water consumption of the DOSCST respondents.

	STUDENT		**FACULTY**		**STAFF**	
	n	%	n	%	n	%
Drinking	300	93.75	44	75.86	23	51.11
Washing	320	100	58	100	45	100
Cooking	24	7.5	5	8.62	3	6.66
Bathing	5	1.56	2	3.44	19.5	43.33

Table 6. Water and health related information.

	YES		**NO**		**TOTAL**
	Total	Mean	Remarks	Total	
Students	1.2	2.4	Most Frequent	319	320
Faculty	0.4	1.6	Always	99.3	58
Staff	0	0	Never	45	45
Total	1.4	4.0		463.3	423

Management Intervention to the DOSCST's Water System

The most urgent and compelling reason why the United Nations declared 1980's as the International Water Supply and Sanitation Decade was on providing clean, safe and potable water for all people. There is a need to make improvements in the water systems design and operational practices. Even though best design and properly installed water system may still end up distributing poor water quality to the consumers, it might be because inappropriate operation and maintenance practices bearing on water quality are not strictly observed.

Routine practices that tend to safeguard water at the source include periodic conduct of sanitary survey by trained technician of physical, chemical and bacteriological tests of waters. Tanks and reservoirs often present opportunities for water to be contaminated. Water in these facilities is not normally under pressure, never completely tight and is completely exposed to various sources of contaminants. There is a need to set up a periodic cleaning program in accordance with the needs. This should include draining brushing or scrubbing, flushing and disinfecting. Also, periodic water examination for bacteria every month and physical and chemical every year must be exercised (Limcolioc et al 1995). Since DOSCST's Water System lacks operation and maintenance by skilled and trained technician, administrations of the college must hire one in order to properly ensure the quality of water supply The sanitary measure practiced to the concrete tanks must be maintained every week of the month. It must be well drained, soaped and brushed with the use of chlorine and detergent powder to wash away and get rid of the dirt that might stick on the surface of the tank (Pers. Comm. 2006). Moreover, the presence of coliform bacteria indicated fecal and non-fecal contamination of water supply. Water pipe system inspection must be conducted by trained or skilled technician and chlorination in water supply must also be observed.

Conclusion

The Most Probable Number (MPN) of coliforms were higher than its standard normal limits. These results determined that the water is not suitable for drinking. There were four identified genera of coliforms in the water sample: thermotolerant bacteria, *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. The four genera of coliform bacteria were found in Stations 1, 2, 4, 6 and 7. The *E. coli* was absent in Stations 3 and 8 while P. aeruginosa was absent in Station 5. Its presence in the water sample indicated fecal and non-fecal contamination of the water supply Even though large in population, students seldom used water. The faculty had used it frequently. On the other hand, staff consumed water most frequently. Moreover, students most frequently experienced water related problems such as skin rashes and stomach disorders compared with the faculty who always had experienced them too. However, the staff had not experienced any disorders at all.

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