Polarized Transmitted Light Microscopy and Scanning Electron Microscopy of Asbestos in the Drinking Water in Selected Areas in Mindanao State University-Main and Marawi City in the Year 2012 and 2014

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Abstract

Over the years, the asbestos cement pipes both in Mindanao State University-Main and Marawi City were not totally replaced and in this study, the microscopic visual counting of asbestos by Polarized Transmitted Light Microscope (PTLM) under crossed-polars coupled with Scanning Electron Microscope-Energy Dispersive X-ray Spectroscopy (SEM–EDX) was used in the determination of the gross number of asbestos fibers, elemental and morphological analyses present in water samples. Results obtained both in PTLM and SEM-EDX analyses in 2012 and 2014 show that the asbestos fibers have the same physical characteristics, and through elemental analysis it was confirmed that the asbestos fibers belong in serpentine and amphibole families. The mapping shows that the most predominant asbestos habit among the four forms observed was fiber followed by acicular, asbestiform and filiform, and among the sampling sites, the water samples in Banggolo contained the most number of asbestos habits while Second Street and Pamping has the least in the respective years. The asbestos fibers in water samples are little in amount, yet, asbestiform, present in water samples in all sampling sites, once ingested is not easily cleared out from the biological system and tends to accumulate with time.

Keywords: Polarized Transmitted light Microscopy, Scanning Electron Microscopy, Asbestos

Introduction

Asbestos is a naturally occurring material with thin microscopic fibers. It is widely used in industries due to its versatility since its fibers are heat resistant and has unique insulating properties. Asbestos is one of the most important minerals used around the globe due to its variety of applications. Usually, they are found in paper products, cement products, floor tiles, roofs, plumbing, appliances, fireplaces and window caulking, friction products such as automobile clutch and transmission parts. Asbestos containing materials have been useful for people for over a thousand years and it became more popular in the early 1900's and onwards since it has been in construction and industries including water systems. However, if products containing asbestos are disturbed, the tiny fibers are released into the air. When they are breathed in, they can become trapped in the lungs and stay there for many years. Over time these fibers can accumulate and lead to serious health problems like mesothelioma, asbestosis, lung cancer and even increase in the risk of developing benign intestinal polyps. This is the reason why asbestos cement pipes were replaced with polyvinyl chloride (PVC) pipes nowadays.

In Mindanao State University- Main Campus, Marawi City, PVC pipes that have been installed are segmented, therefore, not all asbestos cement pipes were replaced with PVC pipes. Several pipe lines in Marawi City are still made up of old pipes containing asbestos. This research aimed to investigate the level of asbestos in the drinking water from the selected areas in Mindanao State University-Main Campus and Marawi City in the year 2012 and 2014. Specifically, this study aims to determine the pH of the water sample in each sampling site, to collect three replicates from each of the nine the sampling sites twice at one month interval, to identify and count the asbestos growth habits in each sampling site using polarized transmitted light microscope (PTLM), to compare the results of the study in 2012 and 2014 and to confirm and determine the elements present in the asbestos habit from a representative sample using Scanning Electron Microscope – Energy Dispersive X-ray (SEM-EDX).

The counting of asbestos fibers in the drinking water and blank samples was done using Polarized Transmitted Light Microscope. The same instrument was also used to identify the asbestos fibers. Scanning Electron Microscope coupled with Energy Dispersive X-ray was used for the morphological and elemental analysis of the asbestos fibers. The pH of the water sample was obtained using the digital pH meter.

Methodology

Sample collection

The source of drinking water obtained for the analysis was chosen randomly. There were five sampling areas in Marawi City namely: Amai Pakpak, Banggolo, Dansalan, Pamping and Pangarungan Village, and four sampling areas in MSU-Main Campus: Second Street, Third Street, Fourth Street and Fifth Street. The general principle in Section 1060 of Standard Method for the Examination of Water and Wastewater by APHA was chosen as guide for the water sampling. A faucet was chosen in the sampling. Each bottle was rinsed twice with the source water prior to collection. During the collection of samples, the faucet or valves were not adjusted until enough amount of the water has been collected. Three replicates were obtained for each sampling site.

Table 1 shows the specific sampling locations in each of the sampling sites in MSU-Main Campus and Marawi City.

Table 1. Specific sampling locations for each sampling sites of the study.

Sampling Site	Specific Locations
Second Street	Princess Lawanen Hall-north wing
Third Street	University International House
Fourth Street	Residential house of a faculty of Economics dept.-CBAA
Fifth Street	Boarding house of one of the students of Chemistry dept.
Amai pakpak	Residential house in front of APCES
Banggolo	Family *carenderia* beside JPI
Dansalan	Family *carenderia* in front of Dansalan College
Pamping	Marawi City Water District
Pangarungan Village	*Sari-sari* store front of Aba Al-khail Computer School

Sampling procedure

Careful cleaning of the polyethylene bottles was done first before the sampling campaigns. During the sampling, hoses or any other forms of fittings were removed first to prevent causes of contamination in the sample. The faucets were allowed first to flow for 1-3 minutes to release any sediment which may settle on the valving works. The faucets were not adjusted until the sampling was complete. Each of these bottles was filled up to 1/3 of the water being the sample, the bottle was shaken vigorously for 30 seconds and the water was discarded. Then, approximately 1 liter of the water sample was obtained allowing the bottle to have some airspace to allow efficient redispersal of settling materials by shaking of the water sample before doing the analysis.

Sample filtration

A 47 mm in diameter porcelain filtering unit was used for the filtration of the water sample. After filtering every batch of samples per sampling site, the filtering unit was immediately washed with detergent solution and rinsed with deionized water.

The filtering unit was then attached to a Buchner flask which side-arm was attached to the tube of the Sibata water pump. Two pieces of filter paper formed into a circle was fitted to the filtering unit. The filter papers were moistened with deionized water. Then a mix cellulose ester (MCE), with 0.45 microns pore size filter was placed on top of the support pad. Deionized water was then added to moisten the filters. Vacuum was then applied so that air bubbles will be excluded and that the filters be at the center of the filtering unit.

When the filtering assembly was already prepared, 20 mL of deionized was poured into the filtering unit and was covered. Immediately, the container having the water sample was shaken and poured into the filtering unit. Vacuum was applied and the filtration was done.

After the filtration of the sample was done, the MCE filter was carefully removed, using the forceps, and transferred into a pre-cleaned and labeled petri dish. This was then dried in an oven at 65-70°C for at least 12 hours with its cover slightly open. The petri dish with samples was placed in an air tight desiccator with its cover completely closed to avoid sources of contamination from the atmosphere.

DMF-acetic acid method

A drop of clearing solution 35% dimethylformamide [DMF], 15% glacial acetic acid and 50% water [v/v] was placed on a clean microscope slide. Enough solution was used to saturate the filter. The filter segment was carefully laid, with sample surface upward, on top of the solution, the filter and solution was brought together at an angle of about 20° to help exclude air bubbles. Any solution not absorbed by the filter was removed using a tissue paper. The slide was then labeled. The slide was then placed in an oven at 65-70°C for 5 to 10 minutes.

Gross examination and asbestos structure counting

The polarized transmitted light microscope was used to identify and quantify the presence of asbestos in each of the prepared slides. This microscope is available at the Geology Department, College of Engineering of the

University of Southeastern Philippines, Davao City. It is an Olympus PM-10 polarized transmitted light microscope with x4, x10, and x40 objectives with x10 wide field eyepieces. The microscope is composed of a gypsum plate, G-22 Walton Beckett graticule, 100 Watt illuminator, whippled disc, rotating position condenser with oversized phase rings, color illumination and a rotating mechanical stage.

The number of asbestos particles was determined and counted following description of the US-EPA Method 100-2 by manipulating the microscope at x10 magnification. No restrictions were applied upon counting the particles as long as the asbestos habit was met. The data were then tallied and recorded.

Specimen preparation for scanning electron microscopy

The scanning electron microscope coupled with energy diffusing X-ray (SEM-EDX) was used for the elemental and morphological analysis of asbestos fibers. This microscope was available at the Material Science Laboratory, Physics Department, College of Science and Mathematics, Mindanao State University- Iligan Institute of Technology.

Using a glass cutter, selected mounted slide of the water sample was cut into a small piece and was mounted for the SEM analysis. After mounting the sample, it was placed inside a platinum coater in order for the sample to become electrically conductive. Making the sample electrically conductive makes the SEM analysis easier and faster.

After this, the sample was loaded and scanned to find the asbestos habit to be analyzed. The habit was captured at x150 magnification. It was then observed at 2000x magnification. A line was drawn in the magnified habit and was used for the elemental analysis. A spectrum was then obtained giving the peaks of the present elements in the sample.

Results and Discussion

One way ANOVA of the first sampling, second sampling and of the means of the two sampling campaigns

Using the PTLM, four habits were observed in the samples. The four habits were identified and quantified based on the description of Campbell (1977). **Table 2** shows the tabulated results of the one-way ANOVA of the asbestos habits counted per sample in different sampling sites for the first sampling campaign.

Table 2. Tabulated results of One-way ANOVA of asbestos habits counted per sample in different sampling sites for the first sampling.

Sampling Site	pH	Asbestiform	Filiform	Acicular	Fiber	p- value	Interpretation
Second street	6.5	16.00	1.33	1.67	18.67	0.078	NS
Third street	6.7	13.00	5.00	31.33	23.67	0.030	S
Fourth street	6.7	3.33	0.67	4.67	29.00	0.042	S
Fifth street	6.6	4.67	2.67	30.33	17.67	0.012	S
Amai Pakpak	6.7	16.67	0.67	2.67	54.67	0.023	S
Banggolo	6.7	4.67	6.33	16.67	79.67	0.022	S
Dansalan	6.6	7.00	4.67	4.67	28.33	<0.000	S
Pamping	6.7	0.67	0.00	0.00	11.00	0.023	S
Pangarungan village	6.8	1.67	1.67	0.00	23.00	0.032	S

Based on the obtained statistically evaluated data, among the nine sampling sites, only in Second Street has no significant difference among the four forms of asbestos present in a liter sample with a p-value of 0.078. Highest counted form of asbestos was fiber and then with asbestiform, acicular and filiform.

In Third Street, acicular has the highest number among the four forms, followed by fiber, asbestiform and filiform. The obtained p-value is 0.030 which means that all forms have significant difference.

Fiber has the highest number per liter sample in Fourth Street. This was followed by acicular, asbestiform and the least is the filiform with a p-value of 0.042 which implies that there is a significant difference among the four structures.

In Fifth Street, acicular has the highest number followed by fiber, then of asbestiform, acicular and filiform as the least. The p-value obtained was 0.012 which signifies a difference in the four forms.

Then in Amai pakpak, fiber has the highest number counted. This was followed by asbestiform, acicular and filiform with a p-value of 0.023 which again implies a significant difference among the forms.

Fiber has the highest number counted in Banggolo, followed by acicular, filiform and asbestiform. The p-value obtained was 0.022 which indicates that there is a significant difference among the four forms of asbestos.

In Dansalan, fiber has the highest number of asbestos habit obtained and this was followed by asbestiform, then of both acicular and filiform which has the same value. A significant difference among the four forms was obtained because of the p-value of <0.000.

No filiform and acicular was obtained in Pamping. Fiber was obtained which has the highest value, followed by asbestiform. A p-value of 0.023 was obtained which implies a significant difference among the forms.

Fiber was also the highest in Pangarungan Village, followed by both the asbestiform and the filiform. No acicular was obtained in the mentioned site. A p-value of 0.032 which again implies a significant difference among the four forms of asbestiform.

For the second sampling, four asbestos growth habits were observed again under the PTLM. The habits were then counted. **Table 3** shows the One-way ANOVA of asbestos habits counted per sample in different sampling sites for the second sampling. Based on the obtained data, among the nine sampling sites, only in Second Street and Fifth Street has no significant difference in the four forms with a p-value of 0.065 and 0.300, respectively. The rest has a significant difference.

Table 3. Tabulated results of One-way ANOVA of asbestos habits counted per sample in different sampling sites for the second sampling.

Sampling Site	pH	Asbestiform	Filiform	Acicular	Fiber	p-value	Interpretation
Second street	6.5	8.33	3.00	1.00	20.67	0.065	NS
Third street	6.7	3.33	1.00	13.00	36.67	0.001	S
Fourth street	6.7	25.33	8.00	7.00	28.00	0.023	S
Fifth street	6.6	19.00	7.33	14.33	24.67	0.300	NS
Amai Pakpak	6.7	3.00	0.67	0.67	28.33	0.000	S
Banggolo	6.7	1.33	0.00	1.67	62.67	0.044	S
Dansalan	6.6	4.33	0.33	5.67	40.33	0.039	S
Pamping	6.7	0.00	0.00	1.67	40.33	0.024	S
Pangarungan village	6.8	2.67	0.67	2.33	32.67	0.000	S

In Third Street, fiber has the highest count, followed by acicular, asbestiform and filiform. The four habits show significant difference with a p-value of 0.001. In Fourth Street, fiber has also the highest count followed by asbestiform, filiform and acicular. Statistics shows that it has a significant difference with a p-value of 0.023.

Amai Pakpak and Pangarungan Village show significant differences in their asbestos growth habits with both having a p-value of <0.000. Fiber was the highest obtained habit, followed by asbestiform, acicular and of filiform as the least.

In Banggolo and Dansalan, the highest counted form was fiber, followed by acicular, asbestiform and filiform as the least. They show significant difference with a p-value of, 0.044 and 0.039, respectively.

No filiform and asbestiform was observed under PTLM in Pamping and fiber has the highest count compared to acicular. The forms have significant difference with a value of 0.024.

Table 4. Tabulated results of One-way ANOVA of asbestos habits counted per sample in different sampling sites for the two sampling campaigns.

Sampling Site	Asbestiform	Filiform	Acicular	Fiber	f -value	p-value	Interpretation
Second street	12.17	2.17	1.33	19.67	7.269	0.064	NS
Third street	8.17	3.00	22.17	30.17	9.497	0.023	S
Fourth street	14.33	4.33	5.83	28.50	9.425	0.024	S
Fifth street	11.83	5.00	22.33	21.17	2.736	0.113	NS
Amai Pakpak	9.83	0.67	1.67	41.50	9.425	0.024	S
Banggolo	3.00	3.17	9.17	71.17	95.918	0.000	S
Dansalan	5.67	2.50	5.17	34.33	50.765	0.000	S
Pamping	0.33	0.00	0.83	25.67	8.440	0.038	S
Pangarungan village	2.17	1.17	1.17	27.83	7.386	0.061	NS

Table 4 shows the One-way ANOVA of the asbestos habits counted per sampling site for the two sampling campaigns conducted. The means of each asbestos habit per sampling site for the two sampling campaigns was tabulated and analyzed. Based on the statistical data obtained, there is no significant difference in the four forms of asbestos in Second Street, Fifth Street and in Pangarungan Village with a p-value of 0.064, 0.113 and 0.061, respectively. While Third Street, Fourth Street, Amai pakpak, Banggolo, Dansalan and Pamping shows significant difference with their results, with a p-value of 0.023, 0.024, 0.024, <0.000, <0.000 and 0.038, respectively.

Descriptive analysis of the fiber contamination

Table 5 shows the average asbestos habits of the four forms in each sampling site. The means of the four habits in each sampling site for the first and second sampling was tabulated. After this, the means of the two campaigns was also obtained and tabulated.

Table 5. Average asbestos counted per liter in first sampling and second sampling

Sampling Site	First Sampling	Second Sampling	Average
Second street	37.67	33.00	35.33
Third street	73.00	54.00	63.50
Fourth street	37.67	68.33	53.00
Fifth street	55.33	65.33	60.33
Amai Pakpak	74.67	32.67	53.67
Banggolo	107.33	65.67	86.50
Dansalan	44.67	50.67	47.67
Pamping	11.67	42.00	26.83
Pangarungan village	26.33	38.33	32.33

Figure 2 shows the histogram of the total fiber concentration in each sampling site for the two sampling campaigns. It shows the average total number of asbestos per liter that were counted in Second Street, Third Street, Fourth Street, Fifth Street, Amai Pakpak, Banggolo, Dansalan, Pamping and Pangarungan Village with the average values of 35.33, 63.50, 53.00, 60.33, 53.67, 86.50, 47.67, 26.83 and 32.33, respectively. The figure also shows that Banggolo has the highest asbestos counted which implies that among the nine sampling sites it is considered to have the highest number of asbestos habits and this was followed by Third Street, Fifth Street, Amai Pakpak, Fourth Street, Dansalan, Second Street, Pangarungan Village and Pamping as the least.

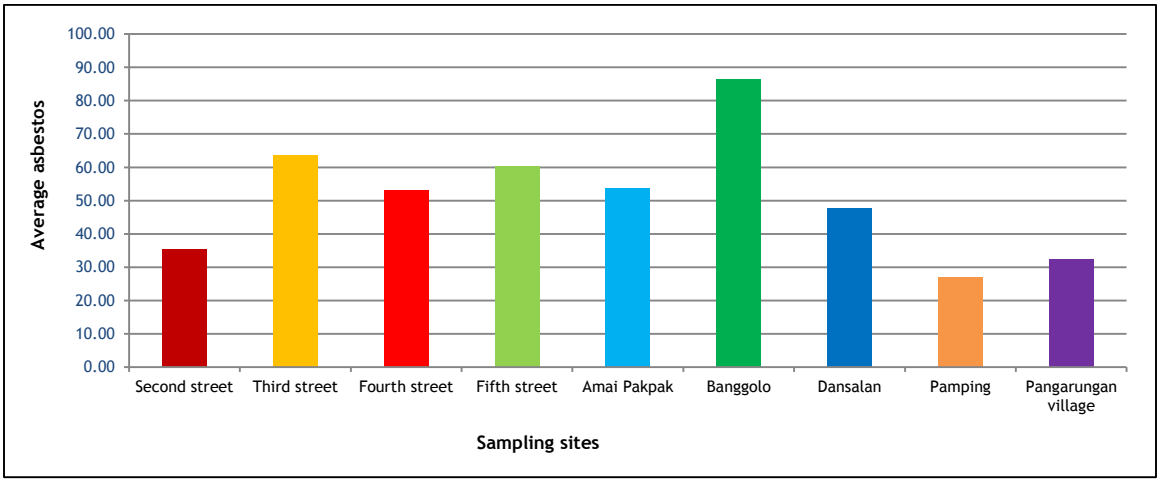


Figure 2. Histogram of asbestos fibers in different sampling areas.

The average values obtained, however, did not exceed the Maximum Contamination Level (MCL) set by the US-EPA which is equal to 7 million fibers per liter.

Asbestos habit distribution

Table 6 shows the average counts of asbestiform, filiform, acicular and fiber for the two sampling campaigns.

Table 6. Average number of asbestos based on growth habit in two sampling campaigns.

Growth habit	First sampling	Second sampling	Average
Asbestiform	7.52	7.48	7.50
Filiform	2.56	2.33	2.44
Acicular	10.22	5.26	7.74
Fiber	31.74	34.93	33.33

Figure 3 shows the histogram of the average number of asbestos based on their growth habit in the two sampling campaigns.

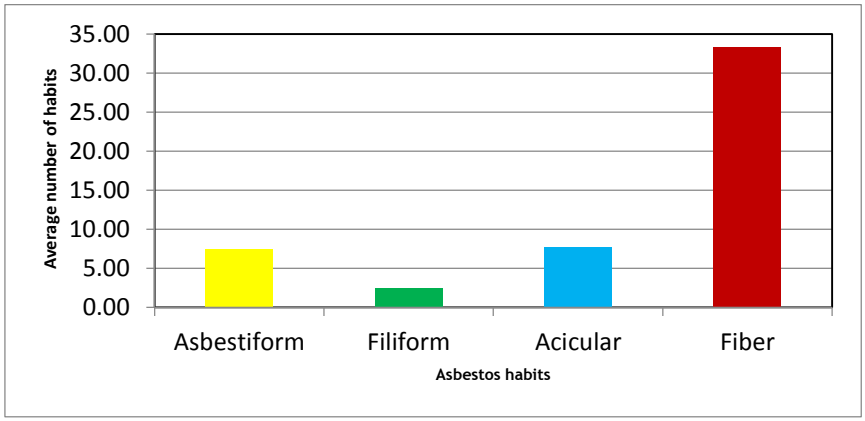
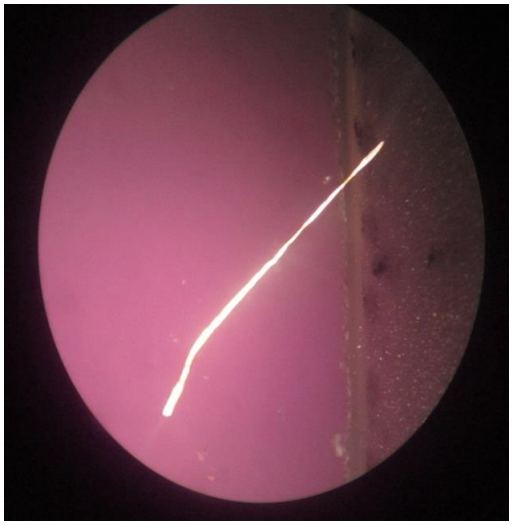
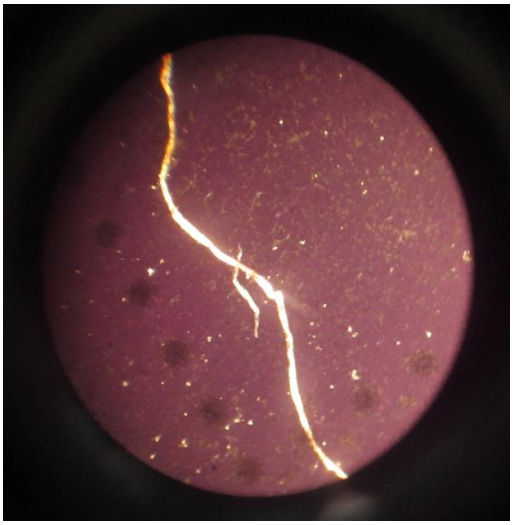
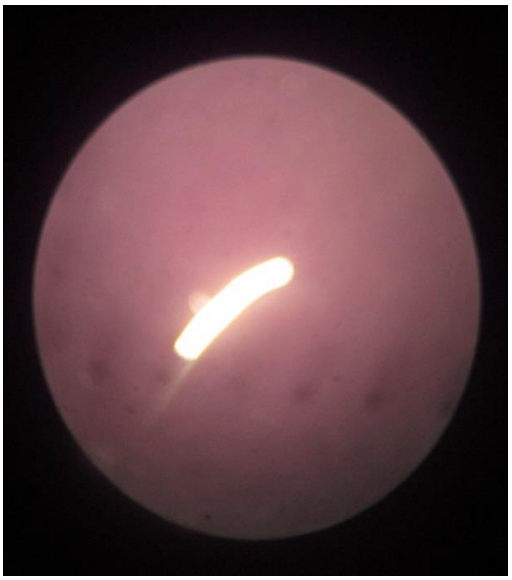


Figure 3. Average asbestos habit distribution of the nine sampling sites.

As shown in **Figure 3**, asbestiform, filiform, acicular were the four asbestos habits found in the nine sampling areas namely, Second Street, Third Street, Fourth Street, Fifth Street, Amai pakpak, Banggolo, Dansalan, Pamping and Pangarungan Village. Among the four habits, fiber is the most widely distributed followed by acicular, asbestiform and filiform is the least.

Asbestos habit: Acicular Source: 4th Street, MSU Main Campus	Asbestos habit: Asbestiform Source: 2nd Street, MSU Main Campus
	
Asbestos habit: Fiber Source: 4th Street, MSU Main Campus	Asbestos habit: Filiform Source: 4th Street, MSU Main Campus
	

Comparison of the previous and present results

The comparison of the previous study conducted by Aquino (2012) and of this recent study was done using Two-Sample t-test (independent variables). Two variables were considered; the sampling site and the asbestos growth habit.

Table 7. Comparison of asbestiform per sampling site in the previous and present study conducted using Two Sample t-test (independent variable)

Sampling site	Asbestiform (2012)	Asbestifom (2014)	t-value	mean difference	p-value	Interpretation
Second street	24.00	12.17	-1.705	-11.833	0.163	NS
Third street	12.50	8.17	-0.724	-4.333	0.509	NS
Fourth street	21.67	14.33	-1.968	-7.333	0.120	NS
Fifth street	17.84	11.83	-2.032	-6.000	0.112	NS
Amai pakpak	24.67	9.83	-3.922	-14.833	0.053	NS
Banggolo	25.67	3.00	-4.177	-22.667	0.014	S
Dansalan	24.50	5.67	-5.201	-18.333	0.018	S

Table 7 shows the statistical analysis of the comparison of the previous study conducted by Aquino (2012) and the present study of asbestiform considering the sampling sites. It shows that there is no significant difference between the results in Second Street, Third Street, Fourth Street, Fifth Street and Amai pakpak, with a p-value of 0.163, 0.509, 0.120, 0.112 and 0.053, respectively. While in Banggolo and Dansalan, with a p-value of 0.014 and 0.018, respectively, has a significant difference. Looking at the mean difference, statistic shows that the previous study is -22.667 higher than the present study for Banggolo and -18.333 for Dansalan. The mean differences in **Table 7** also shows that there were more asbestiform habit obtained in the previous study than in the present study.

Figure 4 shows the histogram of asbestiform habits as compared in the previous and present conducted.

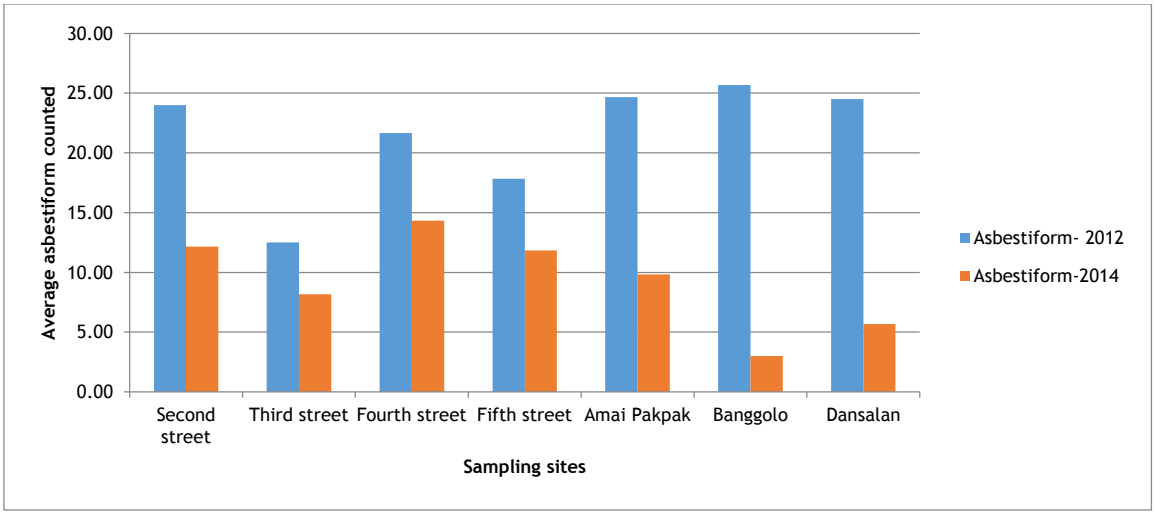


Figure 4. Histogram of the compared asbestiform habit.

Figure 4 clearly depicts the asbestiform habits obtained in the year 2012 as studied by Aquino compared to the recent study conducted. The figure clearly shows that asbestiform obtained in the year 2012 was much higher that the recently obtained in all of the sampling sites. Highest number of asbestiform in the year 2012 study was in Banggolo and least at Third Street. In the recent study, highest was in Fourth Street and least at Banggolo.

Table 8 shows the comparison of the previous and the present study in terms of filiform in each sampling site. The same test was made with that of asbestiform. The comparison of the previous and present study in terms of filiform per sampling site shows significant difference in all of the sampling sites.

Table 8. Comparison of filiform per sampling site in the previous and present study conducted using Two Sample t-test (independent variable)

Sampling site	Filiform (2012)	Filiform (2014)	t-value	mean difference	p-value	Interpretation
Second street	13.50	2.17	-5.185	-11.333	0.013	S
Third street	14.50	3.00	-3.869	-11.500	0.024	S
Fourth street	20.50	4.33	-4.038	-16.167	0.016	S
Fifth street	16.84	5.00	-4.787	-11.833	0.009	S
Amai pakpak	38.50	0.67	-25.250	-16.833	0.000	S
Banggolo	10.67	3.17	-5.582	-7.500	0.005	S
Dansalan	22.34	2.50	-6.018	-19.833	0.004	S

It shows that Dansalan has the largest mean difference, followed by Amai pakpak, Fourth Street, Fifth Street, Third Street, Second Street and Banggolo. The analysis also shows that the previous study has the higher filiform habit obtained than in the present study conducted.

Figure 5 shows the histogram of the filiform obtained as compared using the previous study and the present study. It clearly depicts that filiform obtained in the study of Aquino (2012) has higher filiform obtained than the recent study conducted in all of the sampling sites.

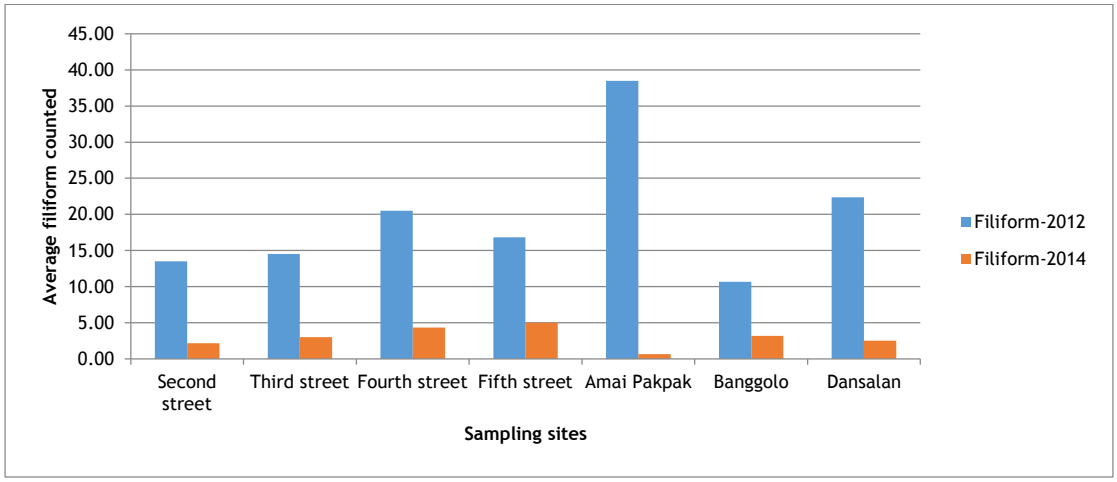


Figure 5. Histogram of the compared filiform habit.

In the year 2012 study, highest filiform obtained was in Amai Pakpak and least at Banggolo. While in the recent study, highest was at Fifth Street and least at Amai Pakpak.

Table 9. Comparison of acicular per sampling site in the previous and present study conducted using Two Sample t-test (independent variable)

Sampling site	Acicular (2012)	Acicular (2014)	t-value	mean difference	p-value	Interpretation
Second street	15.00	1.33	-12.965	-13.667	0.000	S
Third street	23.00	22.17	-0.693	-0.833	0.535	NS
Fourth street	30.00	5.83	-11.919	-24.167	0.007	S
Fifth street	48.34	22.33	-3.622	-26.000	0.022	S
Amai pakpak	24.33	1.67	-8.114	-23.500	0.001	S
Banggolo	30.42	9.17	-7.077	-21.000	0.002	S
Dansalan	33.17	5.17	-7.725	-28.000	0.002	S

For acicular, statistics shows that only in Third Street has no significant difference among the seven sampling sites. The rest shows significant difference with a mean difference value of -13.667 for Second Street, -24.167 for Fourth Street, -26.000 for Fifth Street, -23.500 for Amai pakpak, -21.000 for Banggolo and -28.000 for Dansalan. These mean differences indicates again that more acicular habits were obtained in the previous study than in the present study conducted.

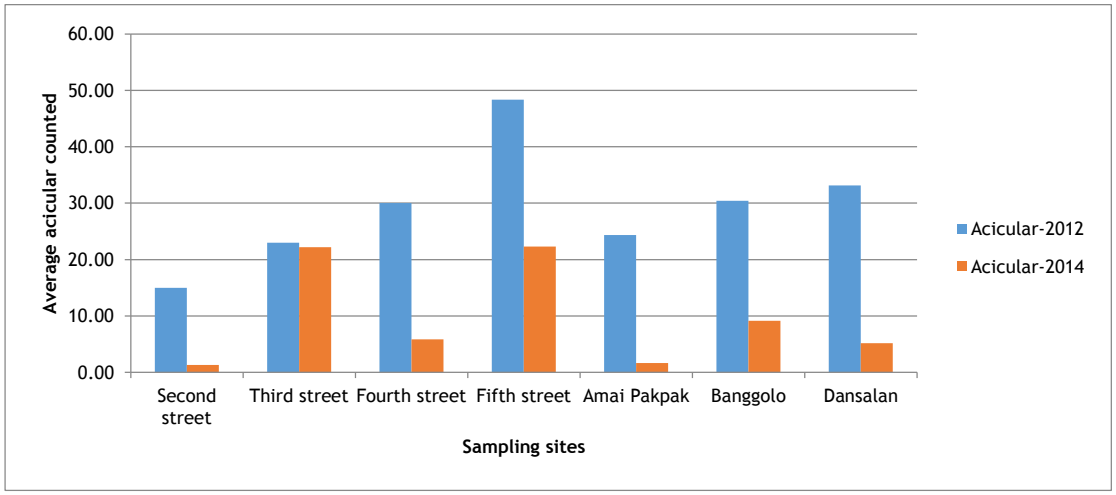


Figure 6. Histogram of the compared acicular habit.

Figure 6 which shows the comparison of the previous and present study in terms of acicular habit, shows that the highest acicular habit obtained was in Fifth Street and Second Street as the least in the year 2012. However, in the year 2014, highest acicular obtained was also in Fifth Street and the least in Second Street also. All of the sampling sites show a decrease in acicular habit in the given range of years.

Table 10. Comparison of fiber per sampling site in the previous and present study conducted using Two Sample t-test (independent variable).

Sampling site	Fiber (2012)	Fiber (2014)	t-value	mean difference	p-value	Interpretation
Second street	19.67	19.67	0.000	0.000	1.000	NS
Third street	28.00	30.17	0.194	2.167	0.855	NS
Fourth street	28.34	28.50	0.038	0.167	0.973	NS
Fifth street	26.84	21.17	-0.688	-5.667	0.529	NS
Amai pakpak	42.00	41.50	-0.054	-0.500	0.960	NS
Banggolo	63.84	71.17	1.148	7.333	0.315	NS
Dansalan	31.84	34.33	0.204	2.500	0.848	NS

Unlike on the filiform habit in which all results show significant difference, fiber shows the opposite (**Table 10**). Meaning, there is no significant difference in the fiber habit for all the sampling sites in the previous and present study conducted. Looking at the mean differences, only Amai Pakpak and Fifth Street has a negative value which means that the previous study has higher fiber habit obtained than in the present study conducted. The rest which has a positive value implies that the previous study has higher fiber habit obtained specifically in Second Street, Third Street, Fourth Street, Banggolo and Dansalan.

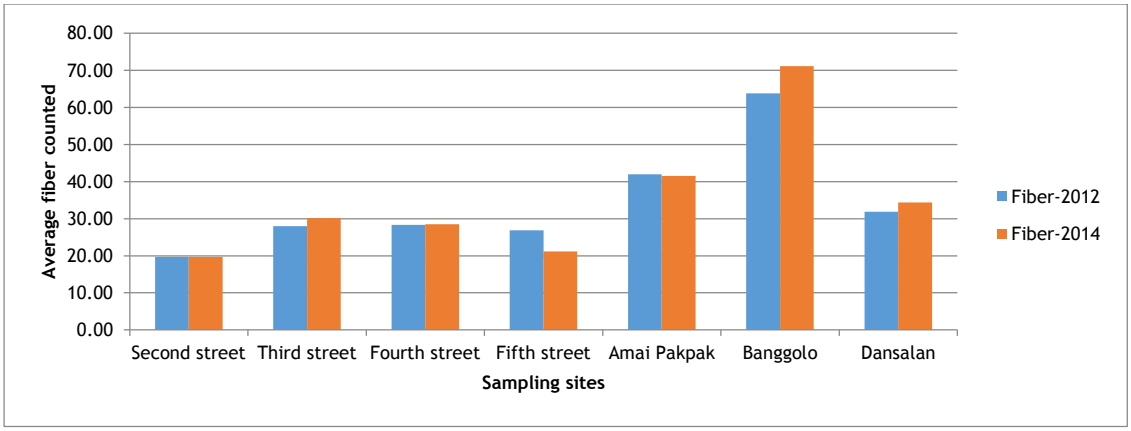


Figure 7. Histogram of the compared fiber habit.

Unlike the other habits, fiber shows an increase in some sampling sites specifically in Third Street, Fourth Street, Banggolo and Dansalan. The other sampling sites show a decrease specifically Second Street, Fifth Street and Amai Pakpak. Highest fiber obtained in the present and previous study was the same which is in Banggolo. Least fiber obtained was also the same which is in Second Street.

Scanning electron microscopy of asbestos fibers

The scanning electron microscope coupled with energy dispersive X-ray spectroscopy was used for morphological feature of the asbestos fibers. The asbestos habit chosen for the analysis was asbestiform. It was then viewed at x150, x2000 and x8000 magnification. **Figure 8**, **9** and **10** show the scanning electron micrograph of the water sample at different magnifications. The electron micrograph shows the asbestiform habit. This chosen habit belongs to the amphibole family.

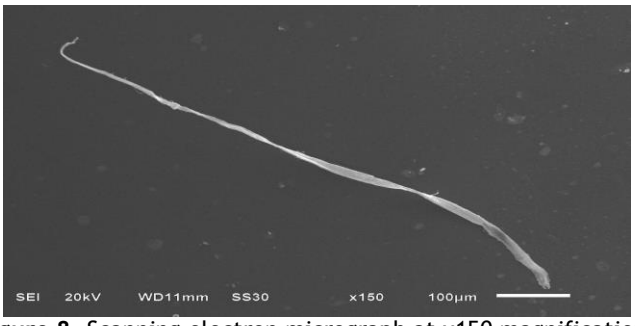


Figure 8. Scanning electron micrograph at x150 magnification.

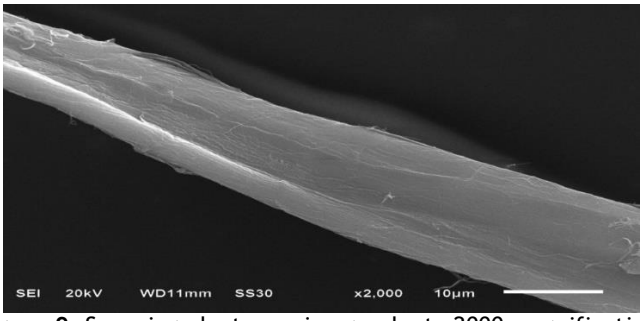


Figure 9. Scanning electron micrograph at x2000 magnification.

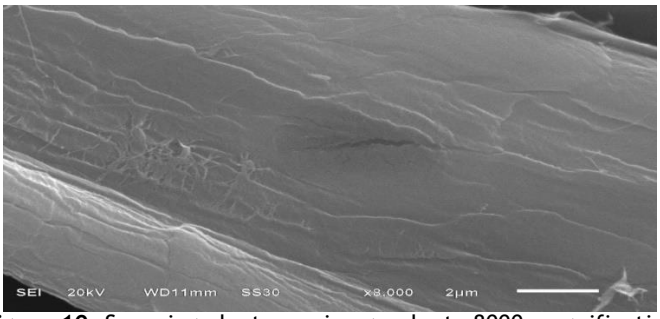


Figure 10. Scanning electron micrograph at x8000 magnification

Elemental analysis of the asbestos fiber

Shown in Table 10 is the elemental analysis of the asbestos habit using scanning electron microscope with energy dispersive X-ray.

The elemental analysis of the chosen habit shows that the elements present were iron, oxygen, sodium, magnesium, aluminum, silicon, calcium and platinum. It should be noted he presence of platinum was just due to the coating of the sample before it was loaded and scanned. Iron has the highest mass percent and calcium has the lowest.

Table 11. Elemental analysis of the fiber using SEM-EDX.

Element	Mass %	Atom %
Fe	48.48	65.34
O	17.49	17.69
Na	4.55	3.21
Mg	1.19	0.79
Al	0.43	0.26
Si	19.38	11.17
Ca	2.61	1.06
Pt	5.88	0.49
Total	100	100

The amphiboles may be considered in terms of five series (1) anthophyllite, (2) cummingtonite-grunerite, (3) tremolite-actinolite, (4) aluminous amphibole, and (5) soda amphibole. The anthopyllite series is orthorhombic while the others are monoclinic. The composition RSiO3 is fundamental to the group with RCa,Mg,Fe. The anthopyllite,

cummingtonite-grunerite and tremolite-actinolite series consist essentially of a range in RSiO3 compositions, while the aluminous and soda amphiboles contain Al and Na in addition to the fundamental composition. The amphiboles have rhombic to pseudohexagonal cross sections and perfect cleavage parallel to {110} at angles of about 56° and 124°. Twinning parallel to {100} is fairly common. The amphibole group is more or less parallel to the pyroxene group. Corresponding members of the two groups, however, are not the dimorphous. Hornblende is by far the most common mineral of the group. Cummingtonite is a pale brown monoclinic amphibole with the composition of anthopyllite. It is rare. Basaltic hornblende is considered a distinctive mineral under the name lamprobolite. Riebeckite, glaucophane, and a few rarer minerals are known as soda amphiboles. The amphibole group is one of the most complex of all mineral groups (Kerr, 1959).

Conclusion

The drinking water that was obtained from the different sampling sites in Marawi City and MSU-Main Campus were found to contain asbestos fibers but of tolerable amount and did not exceed the threshold limit which is 7 million fibers per liter. The asbestos habits namely; asbestiform, filiform, acicular and fiber are all found in each of the sampling sites. With the statistical analysis, it is found that fiber has the most numbered form and filiform has the least which is observed using the polarized transmitted light microscope. And also, Banggolo has the most contaminated-water and Pamping has the least.

Statistical analysis also shows that some show a significant difference with the results and the results of the previous study with respect to the sampling site and the asbestos growth habits. For asbestiform, all of the sampling sites do not have any significant difference for the two studies. For filiform, all of the sampling sites has a significant difference for the two studies conducted. For acicular, only in third street has no significant difference. Lastly, for fiber, all of the sampling has no significant difference for the two studies conducted.

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