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Occurrence Of Soil-Transmitted Helminth And Heavy Metal Contamination In The Vegetable Garden Soils Of Public Schools Of Muntinlupa City, Philippines

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ABSTRACT
Schools are known to be a safe place for students; however, the safety of the schools should not only be evaluated in the macro level but also in the micro level. In the public schools of the Philippines, rare to no activity of microbial and micro toxin evaluation is executed due to the lack of resources and prioritization. The study examined the vegetable garden soil of nine of the most populous schools in Muntinlupa City in each barangay for heavy metal and soil-transmitted helminth contamination. Seven out of nine schools were found to have high cadmium soil contamination while two out of nine have high mercury soil contamination. The occurrence of four genera of soil-transmitted helminths were found in the vegetable garden soil of schools. All schools were found to have Hookworm and *Ascaris* sp. occurrence while two were found to have *Trichuris* sp. occurrence. One school was found to have *Hymenolepis* sp. occurrence. Serious health risks due to acquisition of heavy metal and microbial parasite contaminants can pose threats to students that can affect their academic performance and social interaction. This could also affect professionals and adult employees who work among the participating schools. This shows that micro level health evaluation in the school environment should also be given high-level of attention and support.
Keywords: Environmental Health, Child Health, Neglected Tropical Diseases, Ecotoxicology, Public Health Biology, School Health

INTRODUCTION
Soil is a major resource for humans used to cultivate a wide array of vegetable garden products. In schools, planting and agriculture are a part of the curriculum to children to produce their own food. This program is helpful in instilling self-sufficiency to students. However, if not properly oriented in soil handling, students can become vulnerable to soil contamination, especially with soil – transmitted helminthic (STH) parasites and heavy metals (Syers and Gochfeld 2000; Hedley and Serafino Wani 2015).

As cited by Aclan et al. 2012, children tend to ingest and inhale an estimated one teaspoon of soil in several occasions, especially when they are playing outside their home. Soil is composed of various minerals and organic matter. The deposition of heavy metals in soil pH during percolation results to the additional reaction in the soil organic matter. Plants can also uptake heavy metals from the soil and be stored in the fruits and leaves leaves (Tangahu et al 2011; Cortez and Ching 2014; Jan and Parray 2016).

Accumulation of heavy metals in plants is not reduced by heating and cooking (Hajeb et al 2014; Kananke et al 2015).

Soil – Transmitted Helminths affects around 8 million of children around the world, causing diarrheal, chronic and acute diseases that may lead to child mortality (WHO 2016). The common helminthic parasites in the Philippines like *Ascaris* sp., *Trichuris* sp., and hookworms are causes of intestinal diseases and malnutrition among children (Belezario et al 2005). The prevalence of these parasites is connected to the type of hygiene and sanitation and in the presence of domesticated animals as these worms are transmitted due to fecal contamination of the environment (Tavalla 2012; Grimes et al 2014). The heavy intensity of infections of these worms among children can affect their physical and cognitive development and may result to micronutrient deficiency including iron-deficiency and anemia, which makes the students perform poorly in school (WHO 2016).

Considering that students are required to do vegetable garden activities in schools, there is a high possibility that they can be exposed to STH and heavy metal contamination. Research shows that soil-transmitted helminths infection and heavy metal toxicity among children significantly affects their health, nutritional acquisition and academic performance (Jan et al 2015; Buntoro et al 2017).

This exposure to STH and heavy metal assessment in the vegetable garden soils in the public schools is never done due to policy, manpower and fiscal constraints. Initiating activities regarding the testing of the vegetable garden soil contamination among the schools would be a promising start to develop more reliable policies and programs in avoiding environmental risks and hazards. This way schools and stakeholders can establish a healthier and safer learning environment for the students.

This study aims to assess the current physicochemical characteristics and heavy metal contamination in the vegetable garden soils of the public schools as well as the potential health risks that these contaminations pose among the school children through the computed hazard quotient (HQ) of the measured data. The study also corroborates the presence of soil-transmitted helminth parasites that are present in the public schools of Muntinlupa City.

MATERIALS AND METHODS

Soil Sample Collection

The samples were taken from the school vegetable garden area where growing vegetables and fruits are located. This site has been frequently used by the students during their Technological and Livelihood Education – Agriculture (T.L.E. – Agri.) class. Samples were collected from 6:00am to 12:00pm, where STH are most active. At least 500g of soil were collected from the vegetable garden sites of the public schools. Vegetable garden areas were divided into three sub areas. Three sets of samples were randomly collected from each site about 3cm to 5cm of the top soil. The samples were mixed together to form a representative sample. Soil samples were collected using sterilized shovels and were placed to a zip lock polyethylene plastic bag and placed in a cool dry container. Samples were then delivered to the laboratory for analysis.

Soil Physicochemical Analysis

The researcher used modified methods in identifying the physicochemical status of the soil (Edori and Iyama 2017). The soil temperature was measured using a pilot hole which was made using a screw driver 3cm to 5cm deep. The thermometer was inserted to the hole for two minutes. The soil pH was measured using the pH Meter stick. The reference electrode was inserted on top of moist soil surface. The electrode of the pocket pH meter was rinsed with distilled water between each soil sample readings. There were three readings per samples. The moisture of the soil was measured by collecting 50g of the representative sample. The soil was desiccated for three days, then the mass of the desiccated samples was measured using the analytical balance. The percentage of the lost weight was calculated. The organic matter (carbon content) was determined by taking 10g of soil sample at 360ºC for 2hrs in the muffle furnace. Percentage of the remaining mass of the soil sample was calculated.

Soil temperature is important since it facilitates the amount of energy that is being absorbed by the soil; thus, affecting the dynamics of the chemical, physical and biological processes. Soil pH is mostly considered when analysing the kind of soil samples since it affects almost all the physicochemical parameters because of the reaction of the hydrogen and oxygen molecules.

Moisture refers to the amount of water that the soil holds as it affects the ability of the soil to absorb nutrients (Kekane et al 2015). The amount of organic matter is proportional to the usefulness of the soil in vegetable garden practices; however, this property is inversely proportional to the pH as it can make the soil acidic (Tale and Ingle 2015). The overwatering among plants results to high amount of moisture in the soil of School G that tends to facilitate the faster dispersal of the organic matter; thus, yielding the least percentage of organic matter in the soil samples of the school (Kanwar et al 1988; Martin et al 2012).

Heavy Metal Analysis of Soil Samples

A 15g of vegetable garden soil samples were air dried and sieved through a muslin cloth into the 50mL falcon tube. 20 mL of extracting solution [0.05N of Hydrochloric Acid + 0.025N of Sulfuric Acid] was added to the falcon tubes and the tubes were mechanically shaken for 15 minutes. The solutions were then filtered through Whattman filter paper #3. Filtered solutions were then combined with the extracting solution until it reaches 50mL. These solutions were subjected to the Atomic Absorption Spectroscopy (AAS) for Heavy Metal measurement. The machine was set for the measuring of Cadmium, Chromium and Lead. Another 15g of soil samples were collected and immediately delivered to the InterTek™ Makati for Mercury testing.

Identification of Soil – transmitted Helminths Identification

The researcher executed the modified sugar centrifugal flotation technique to separate egg specimen from the soil (Matsuo and Kamiya 2005; Amoah et al 2017; Steinbaum et al 2017). Five hundred grams of top soil sample were taken from four quadrats and center of the vegetable garden area of the schools and were then delivered to the lab. The soils were mixed and 10g of soil from the sampling bag was placed into the 50mL beaker together with the 40mL 10% Tween 80 floatation solution. The floatation solution was carefully stirred with the glass rod and was poured into the centrifuge tube. Tubes were then subjected to centrifugation at 1200 rotations per minute for 5mins. Tubes were removed and were filled with additional floatation solution to ensure that STH eggs will reach the top. A coverslip was placed on top of the centrifuge tube. An air bubble under the cover slip was observed to confirm if the correct amount of floatation fluid is added. The set up was set aside for 30 minutes. The cover slip was placed on the slide and examined under the light microscope with 400x magnification on OIO for identification of the parasite. The set up was done three times for replicates. The description characteristics and morphology of the specimens were compared to online database and textual references.

Statistical Analysis

Data on the physicochemical characteristics of the soil includes soil pH, temperature, organic matter and soil moisture. Temperature is measured in Celsius while organic matter and moisture content are measured by percentage. Organic matter is calculated by dividing the mass of ash of the furnaced soil to its original mass multiplied by 100. The moisture of the soil is taken by dividing the mass of the desiccated soil to its original mass multiplied by 100. Heavy metal contamination of Cadmium, Lead, Mercury and Chromium in the soil were presented in mean of three readings. Values were compared to the standards set by the USEPA, PNSW and WHO.

The Hazard Quotient (HQ) was computed as the ratio between the measured values as compared to the standard values (Galarpe and Parilla 2014; Fowle and Dearfield 2017). The farther the computed HQ value from 1.0, the greater the environmental risks (Galarpe and Parilla 2014; Fowle and Dearfield 2017).

The soil-transmitted helminths were presented by the total number of eggs and worms observed from prepared slides. The examined cover slips were observed under the light microscope with 400x magnifications under oil immersion objective.

RESULTS AND DISCUSSIONS

Physicochemical Characteristics of Soil

Soil temperature and pH in all public schools are within the standard limits (Table 1). However, soil moisture content varies among the schools, and none of the schools have reached the ideal limit for a healthy soil. Only School G has recorded an ideal amount of 54%. In terms of organic matter, School B recorded 6.798% of organic matter while School H with 6.958%.

Table 1. Physicochemical characteristics of vegetable garden soils in the public schools of Muntinlupa city

School	Soil pH	Temperature (^{o}C)	Moisture (%)	Org Matter (%)
Acceptability values set by the USEPA and PNSW	6.00-8.5	20-60	25-50%	3 – 6%
School A	7.57	29.40	13.50	5.566
School B	7.55	29.50	16.60	6.798
School C	7.40	30.00	16.24	5.963
School D	7.41	31.20	16.28	5.541
School E	7.68	29.40	12.96	5.350
School F	7.14	29.20	23.60	4.513
School G	7.51	30.20	54.80	3.457
School H	7.35	31.60	10.40	6.958
School I	7.58	27.80	16.38	5.315

Highlighted (green) values exceeded the acceptable limit of the physicochemical requirement of the soil.

Soil temperature is important since it facilitates the amount of energy that is being absorbed by the soil; thus, affecting the dynamics of the chemical, physical and biological processes. Soil pH is mostly considered when analysing the kind of soil samples since it affects almost all the physicochemical parameters because of the reaction of the hydrogen and oxygen molecules.

Moisture refers to the amount of water that the soil holds as it affects the ability of the soil to absorb nutrients (Kekane et al 2015). The amount of organic matter is proportional to the usefulness of the soil in vegetable garden practices; however, this property is inversely proportional to the pH as it can make the soil acidic (Tale and Ingle 2015). The overwatering among plants results to high amount of moisture in the soil of School G that tends to facilitate the faster dispersal of the organic matter; thus, yielding the least percentage of organic matter in the soil samples of the school (Kanwar et al 1988; Martin et al 2012).

Heavy Metal Contamination in the Soil

Table 2. Heavy Metal presence in the vegetable garden soil samples of Public Schools

School	Cadmium (ppm)*	Mercury (ppm)*	Chromium (ppm)*	Lead (ppm)*
Acceptability values (USEPA and WHO)	<0.76	<1.9	<3.8	<0.55
School A	1.2619	0.28	< 0.001	< 0.001
School B	0.6531	3.00	< 0.001	< 0.001
School C	0.9575	0.03	< 0.001	< 0.001
School D	1.2619	0.04	< 0.001	< 0.001
School E	1.0336	0.01	< 0.001	< 0.001
School F	1.0336	0.01	< 0.001	< 0.001
School G	0.8053	3.17	< 0.001	< 0.001
School H	0.6150	0.02	< 0.001	< 0.001
School I	1.1478	0.02	< 0.001	< 0.001

Highlighted (green) values exceeded the acceptable limit.
**ppm=parts per million*

The contamination of heavy metals among schools could be associated with the utilization of pesticides and fertilizers as well as the air-borne sources such as gas vapors and dust particles (Wuana and Okieimen 2011). The presence of heavy metal on the soil can be facilitated by the high moisture content of the soil as it can slow down the chemical interaction and absorption of metals to the soil (D'Amore et al 2005). Mercury could be released in the air by microchip manufacturing companies, vehicle manufacturing companies and gasoline stations near the schools and eventually fall down to the ground due to rainfall or gravity (Won et al 2007, USEPA 2020). Biosolids such as manures and water sewage sludge could also contribute to the higher levels of cadmium and mercury, since these are added to the fertilizers added to the school vegetable garden soils (Basta et al 2005). Traces of cadmium sample from the soil samples can also be associated plastic drums and painted tires in the vegetable garden areas of the schools, since cadmium is used to facilitate the impact of fertilizers, prolonging the longevity of plastics and paints (Wuana and Okieimen 2011). Generally, the contamination of mercury and cadmium in these two schools is anthropogenic in nature (Xu et al 2015; Navarette et al. 2016).

Table 3. Result of Hazard Quotient (HQ) computation for the heavy metal contamination of vegetable garden soil in the public schools of Muntinlupa City

School	Cadmium (ppm)*	Cadmium	Mercury (ppm)*	Mercury
Ideal Result	<0.76	**<1.0**	<1.9	**<1.0**
School A	1.2619	1.660	0.28	0.147
School B	0.6531	0.859	3.00	1.579
School C	0.9575	1.260	0.03	0.016
School D	1.2619	1.660	0.04	0.021
School E	1.0336	1.360	0.01	0.005
School F	1.0336	1.360	0.01	0.005
School G	0.8053	1.060	3.17	1.668
School H	0.6150	0.809	0.02	0.011
School I	1.1478	1.510	0.02	0.011

Highlighted (green) values exceeded 1.0 for Hazard Quotient (HQ).
**ppm=parts per million*

The result of hazard quotient is parallel to the result of the number of heavy metals found in the soil samples of different schools with regard to their respective permissible limits as shown in Table 3. All the schools are facing hazard risks in terms of heavy metal poisoning, except for School H. Heavy metals were detected in the soil of all schools (Table 2). Cadmium (Cd) contamination was observed in highest in School D, mercury (Hg) contamination is highest in School B and School G.

School H is the lone school to be free of heavy metal contamination since they limit the use of fertilizers and imported soil in their vegetable garden areas. Aside from this, the school is situated in a residential area and accessible via minor road. Vehicles that pass by the area and influence of industrial factories are minimal as compared to other schools.

The presence of cadmium and mercury in the vegetable garden soils of the public schools suggests that children and other people in the schools expose to these toxins are at risks of heavy metal poisoning. Biomagnification and bioaccumulation of these toxins will eventually exceed the limits of heavy metals presentt in the human body (Ali and Khan 2018). Since the vegetables that are used in the feeding program can uptake the heavy metals from the soil, children are therefore more susceptible to immunosuppression, bone and brain damages, organ failures – especially the kidneys, nerve fibers and disruption of cognitive development (Oslon 2018).

Severe exposure to cadmium may result in pulmonary effects such as bronchiolitis, emphysema, and alveolitis (Kabata-Pendias 2011). Cadmium can also result in bone fracture, kidney dysfunction, hypertension and even cancer (Khan et al. 2013). Arthritis, diabetes, anemia, cardiovascular disease, cirrhosis, reduced fertility, headaches and strokes are some of its odd long-term effects. Once cadmium is in soil, it is persistent and cannot be broken down into less toxic substances in the environment. Students, teachers, and other people in the school were also at health risks because of the presence of mercury. Exposure to mercury affects brain development, resulting in a lower IQ, and consequently a lower earning potential and one of its sources is cement production (Bose – O'Reilly et al 2010; USEPA 2020). The presence of mercury in the soil of all these schools may be contributed by the on-going construction of new buildings and cement dusts are being inhaled by the students, teachers, and others.

The high concentration of cadmium and mercury were also observed in the water samples and dusts collected from the participating school. This means that heavy metal contamination is not only limited to soil, but also to the water used for the plants. Heavy metals like cadmium and mercury in a form of mercury oxide can also be acquired by the plants and humans (Tangahu 2011; Viehweger 2014).

Soil – Transmitted Helminths in the Vegetable Garden Soil

Table 4. Prevalence of soil-transmitted helminths in vegetable garden soil of public schools of Muntinlupa City

Genera	School A	School B	School C	School D	School E	School F	School G	School H	School I	Total
Hookworm	6 (37.50)	4 (36.36)	3 (25.00)	4 (40.00)	3 (25.00)	6 (24.00)	4 (23.53)	4 (33.33)	3 (30.00)	37
Ascaris spp.	10 (62.50)	7 (63.34)	8 (66.67)	6 (60.00)	9 (75.00)	14 (46.00)	13 (76.47)	8 (66.67)	7 (70.00)	82
Trichuris spp.	0	0	1 (8.33)	0	0	3 (12.00)	0	0	0	4
Hymenolepis spp.	0	0	0	0	0	2 (8.00)	0	0	0	2
Total	**16**	**11**	**12**	**10**	**12**	**25**	**17**	**12**	**10**	**125**

Note: Number of STH (Prevalence (%)

The prevalence of four genera of parasites were identified in the soil samples (Table 4). *Ascaris* sp. and hookworm were the most prevalent with 82 and 37 individuals respectively. *Trichuris* sp. and *Hymenolepis* sp. are at third with a significantly low number of 4 and 2 individuals respectively.

Seven out of nine schools have two genera of parasites found in their vegetable garden soil, which means that students from this schools can acquire dual infection. Triple infection can occur among the students of School C while multiple infection can occur among the students of School F. It is observed that toiletries, dumpsites and septic tanks are near in all the vegetable garden areas of the schools which can be a factor for the prevalence of the parasites.

All the organisms found in the soil samples of public schools are usually found in the Philippines and have adverse effects on human health, especially in children who are more likely to acquire helminthic infections due to their behaviours and daily school activities (Belizario et al 2011; Ross et al 2014, Belizario et al 2016). The acidic soil of the schools is favourable for the prevalence of these parasites (Yapi et al 2016).

Hookworm infection among humans rarely leads to death; however, it can be the cause of iron-deficiency anaemia and malnutrition. The chronic exposure to hookworm infection can also lead to lethargy, impaired physical and cognitive development and possible effects on pregnancy outcomes. Hookworm infection can be acquired through ingestion and dermal entry, and since students and school personnel are doing vegetable garden activities with bare hands, the risks of infection among these group is high (CDC 2017). This means that students who may be exposed to this infection cannot perform well in school because of their inability to focus leading to their poor academic performance; likewise, school personnel like the vegetable garden teachers and helpers can also be exposed and suffer from the same symptoms that can make them incapable of doing their tasks over a period of time. Bartsch et al (2016) confirmed that hookworm infection can affect economic impact even though it may not lead to death, since it keeps the infected population to contribute to the organization where they belong.

Ascaris sp. can be acquired through dermal and ingestion entry when person is exposed to contaminated soil, and in some cases, it can be transferred from human to human (Else et al 2020). They can cause bowel obstruction to pancreatitis, malnutrition, fatigue and fever among infected children (Hall et al 2008). Heavy infection of this parasite can lead to intestinal blockage, and poor growth and development among children (CDC 2017). Ascariasis can also be acquired when vegetables are not carefully cooked, peeled or washed (Kafle 2014). This means that if the school will not take such contamination seriously, the vegetables that are being served to students and school personnel form the vegetable garden can lead to parasitic infection of *Ascaris* sp., making the students become more prone to diseases and health problems.

The other two identified soil-transmitted helminths in the vegetable garden soil samples are *Trichuris* sp. and *Hymenolepis* sp.. Although significantly low in number the two genera of parasitic worms can still cause adverse health impacts among students and school personnel. *Trichuris* sp. is also known as whipworm that is distributed through the infected human faeces. The eggs from the contaminated faeces tend to be deposited in the vegetable garden soil and can enter the body by putting the dirty mouth near the mouth of the hosts. Worms will then hatch within the body resulting to bowel obstruction, and malnutrition among children (Hall et al. 2008). In addition, Correale and Farez 2017, found a positive correlation of the occurrence of multiple sclerosis among patients infected with whipworms. On other hand, *Hymenolepis* sp., a genus of tapeworm, that causes hymenolepiasis, belongs to the group of neglected tropical diseases (CDC 2014). The infection of this parasite is usually asymptomatic but can cause diarrhea, jaundice, headaches, fever, and fatigue and in some cases, death, when not medically given proper attention, especially among rural communities (Cabada et al 2018). Looking at its effect and health impacts, students who can be infected of these two parasites are also at risks of performing poorly in their academics as they have to focus more on the symptoms and clinical complaints rather than on the school activities (Sewilam et al 2021).

Infections with helminths are global public health threats and are closely associated with poverty, unsafe water and inadequate sanitation and hygiene (Bethony et al. 2006). Worldwide, more than 1.5 billion people (24% of the world's population) are infected with STH, mainly including Ascariasis (819.0 million) and hookworm infection (438.9 million). Nearly 70% of the global STH burden occurs in Asia (Pullan et al. 2014). Results of China's second national survey for STH showed that the prevalence of *A. lumbricoides* and *T. trichiura* were 12.7% and 4.6%, respectively (Coordinating Office of the National Survey on the Important Human Parasitic Diseases, 2005).

In the Philippines, soil-transmitted helminth infection is being combatted using the program "Oplan Good bye Bulate!" (DOH 2020). This program implements the national deworming day where students are given medication that can eliminate soil-transmitted helminth infections. The monitoring of students with this kind of parasitic infection is done by school nurses and in the elementary levels only. Infected students are identified through one on one survey with students or with the parents. The awareness of the school authorities regarding the prevalence of the soil-transmitted helminths within the school campuses are not as it is expected to be as majority of them believe that the acquisition of infection occurs outside of the schools.

In 2017, Wardell et al 2017 found in their study that majority of STH infections have long-term ramifications on an individual's health and productivity, contributing to malnutrition, anemia, and impaired childhood growth; and the widespread predicted risk of any STH infection in 6- to 18-year-old provides strong evidence to support strategies for control across the entire geographical area.

CONCLUSIONS

The vegetable garden soil of the tested public schools in Muntinlupa city has a confirmed heavy metal contamination, specifically cadmium and mercury. The computed Hazard Quotient (HQ) shows that majority of the students and school personnel are at risks of the adverse health effects of heavy metals. Chronic exposure to these contaminations can lead to the occurrence of biomagnification and bioaccumulation of this toxins that may result to health problems. The study also confirmed the presence of the four genera of soil-transmitted helminths which is mostly composed of hookworm and Ascaris sp.. Traces of *Trichuris* sp. and *Hymenolepis* sp. are also found in the soil samples. The acidity of the soil contributes to the prevalence of the parasites that heighten the risks of infections among students and school personnel. Crops being planted in their soil may be contaminated by cadmium and mercury and will not be safe for consumers. As teachers and students plant crops, they may be infected with STH like hookworm, *Ascaris* sp., *Trichuris* sp., and *Hymenolepis* sp..

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