Home Environmental Health Risks Assessment in Selected Houses in Barangay Buhay Na Tubig, Imus, Cavite, Philippines: A Basis on Sustainable Development Goal 3.9.1 Future Policies and Guidelines

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***Abstract*—Home environmental health risks, particularly indoor air pollution, are increasingly recognized as major contributors to illness, especially among pregnant women, infants, children, the elderly, and those with chronic medical conditions or disabilities. Sustainable Development Goal (SDG) 3.9.1 aims to reduce the mortality rate attributed to household and ambient air pollution. This is measured by the number of deaths per 100,000 individuals caused by indoor and outdoor air pollution. The sources of such pollution include fuel-burning appliances, tobacco products, building materials, household cleaning products, and excess moisture. This study aims to identify home health risks related to indoor air pollution in selected houses in Barangay Buhay Na Tubig, Imus, Cavite. The researcher used questionnaires detailing sources of home health risks. The results revealed a moderate level of hazardous chemicals used in the house. Most homes surveyed expressed concern over not using exhaust fans while cooking. The conclusion highlighted potential sources of injury and illness in the surveyed houses. It is recommended that government agencies create policies and guidelines to educate households on the responsible use of chemicals and promote healthier housing. This will help reduce the risks posed by indoor air pollution and improve overall health and well-being.**

***Keywords*—home health risk, indoor air pollution, hazardous chemicals, ambient air pollution, volatile organic compounds, pollutants, vapor pressure**

I. Introduction

A healthy home environment is an essential component in achieving comfort and peace at home. Home environmental health risk and pollutants present in the house are at pace of creating injury and exacerbation of illness. Long term exposure to this pollutant poses great concerns to the health of the people. These concerns are increasingly recognized as source of injury and exacerbation of illness, among those affected individuals are the pregnant women, infants, children, the elderly, and those living with chronic medical condition or disability.

Indoor air pollution is gaining an increased awareness that may cause sick building syndrome, molds related diseases, and even deaths from carbon monoxide poisoning, which can occur in home environments as well as work environments. The focus of the government agencies is to formulate policies to maintain the quality of outdoor air, but there are no policies regarding indoor air quality. It is the sole responsibility of the homeowners to maintain the quality of indoor air. The household activities that can affect air pollution levels are smoking, frequency use of air fresheners, cleaning products, and pesticides.

Another that is causing problems in the indoor environment is the volatile organic compounds, which are human made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. EPA's Total Exposure Assessment Methodology studies found levels of about a dozen common organic pollutants to be 2 to 5 times higher inside the home than outside. Additional results of these studies indicated that people using these products containing organic chemicals can be exposed to these high pollutant levels and the levels can be retained inside the house for long time. This research studied home environmental risks and will recommend future policies.

II. Literature Review

The Sustainable Development Goal is a plan to achieve a better and more sustainable future for all. They address the global challenges the world is facing right now, including those related to poverty, inequality, climate change, environmental degradation, peace, and justice. There are 17 goals in Sustainable Development Goals that are all interconnected and should be attained by the year 2030. SDG Target 3.9 is the mortality from environmental pollution. This is to reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution, and contamination. Specifically, in 3.9.1, mortality rate is attributed to household and ambient air pollution [1].

The focus of this research is to assess the indoor pollution in the household targeted in Cavite. Indoor air pollution is a concern that is not yet addressed by the government agencies. Indoor air within homes and other buildings can be more seriously polluted than outdoor air in even the largest and most industrialized cities. World Health Organization (WHO) in their research that mostly people spend their time inside the house and this situation can expose the household occupants on a greater risk. Among the people that is vulnerable to this indoor air pollutants are the young, elderly, and the chronically ill, especially those suffering from respiratory or cardiovascular disease. There are numerous forms of indoor air pollution. According to WHO [1], this air pollutant level in the home is accumulated for long periods if the outdoor air cannot dilute emissions from indoor sources and to carry indoor air pollutants out of the home. These indoor air pollutants are categorized into two: biologic and chemical. Biologic pollutants include bacteria, molds, viruses, animal dander, cat saliva, dust mites, cockroaches, and pollen. Pollen is a common pollutant that elicits a variety of

symptoms sneezing, watery eyes, coughing, shortness of breath, etc. Although these symptoms are self-limiting, people having asthma can be at danger of exacerbation. The droppings from cockroaches like saliva can contribute to the biologic sources of indoor pollutants. Pets inside the house that most residents have can be a significant source of pollution, the proteins in the dander, urine, or saliva of warm-blooded animals can sensitize individuals and lead to serious complications of respiratory illnesses. Mold that includes moldlike fungi can trigger various illnesses inside the house. The development of molds in the house is those coming from dripping waters and floors that are not properly cleaned. The illnesses that is associated with molds are infectious diseases caused by histoplasma, toxic effects like the aflatoxin-induced liver cancer from exposure to mold-produced toxin in food. Chemical pollutants are sources of indoor pollution that most people are unaware of. One of the chemicals that may cause a serious effect is carbon monoxide. CO is the leading cause of poisoning deaths. CO-related nonfire deaths are often attributed to heating and cooking equipment. The leading specific types of equipment blamed for CO-related deaths include gas-fueled space heaters, gas-fueled furnaces, charcoal grills, gas-fueled ranges, portable kerosene heaters, and wood stoves. Low levels of CO exposure can cause fatigue and increase chest pain in people with chronic heart disease. Higher levels of CO can cause flulike symptoms in healthy individuals but on the higher exposure of CO can cause loss of consciousness and even death.

Another chemical that is causing indoor pollution is the ozone that is coming from outdoor ozone. Ozone can exacerbate chronic respiratory illness. Ozone is also created by the exposure of polluted air to sunlight or ultraviolet light emitters. Environmental tobacco smoke, also known as "secondhand smoke", is a product of combustion. The National Cancer Institute (NCI) in 2020, states that ETS is the combination of two forms of smoke from burning tobacco products: Side stream smoke, and Mainstream smoke. This smoke coming from tobacco can cause lung cancer even to non-smokers due to ETS.

In modern homes, many organic chemicals are used as ingredients in household products. Organic chemicals that vaporize and become gases at normal room temperature are collectively known as Volatile Organic Compounds (VOC).

Example of common items that can release VOCs include paints, varnishes, and wax, as well as in many cleanings, disinfecting, cosmetics, degreasing, and hobby products. Level of VOCs is higher indoor than outdoors. VOCs that frequently pollute indoor air include toluene, styrene, xylenes, and trichloroethylene. Some of these chemicals may be emitted from aerosol products, dry-cleaned clothing, paints, varnishes, glue, art supplies, cleaners, spot removers, floor waxes, polishes, and air fresheners. The disease that is associated with these VOCs is leukemia from trichloroethylene, babies with neurologic problems are caused by exposure to toluene, xylenes exposures is associated with birth defects. Styrene is a suspected endocrine disruptor, a chemical that can mimic hormones of humans, benzene from tobacco smoking is a human carcinogen source. Even formaldehyde that is an ingredient preservative in paint, can cause various illnesses. In the study conducted by Lin *et al.* [2], that twelve consumer products studied showed a high total VOC content. The emission factor of this VOC was used to better understand the health hazards of these materials.

The World Economic Forum in their article titled "Indoor Air Pollution: What causes it and how to tackle it" [3], discussed the problem of indoor air pollution and the future technology that will address the problem. Saini *et al.* [4] proposed an IAQ monitoring system that will detect indoor air pollution. A similar study was conducted also by Yu and Lin [5], suggested an intelligent wireless sensing and control system to deal with the health issues caused by the pollution. In the article by Settimo [6], titled "Indoor Air Quality: A Focus on the European Legislation and State of the Art Research in Italy", the author mentioned that some countries in Europe already developed a protocols and guides for self-diagnostic activities that is based on scientific knowledge and practical experience on indoor air quality. The conclusion of this study is that those European countries must have a legislative framework to address the indoor air pollution concerns. Sadrizadeh *et al.* [7] conducted research on indoor air quality in schools. It was published in the Journal of Building Engineering. The conclusion of the study was to design a school with an effective ventilation system and measures to protect children against exposure to airborne particles and VOCs.

A study by Wang *et al.* [8] indicated that prolonged exposure to indoor air pollutants significantly increases the risk of developing asthma and Chronic Obstructive Pulmonary Disease (COPD). The vulnerability of pregnant women, infants, and the elderly has also been highlighted in recent studies. Chen *et al.* [9] emphasized the risks of low birth weight and preterm birth due to exposure to particulate matter and carbon monoxide in households using traditional cooking methods. Furthermore, a study by Kapoor *et al.* [10] pointed out the rising concern about chemical emissions from household cleaning products and their contribution to deteriorating indoor air quality. For mitigation, several approaches have been suggested, including improving ventilation and using cleaner fuels. According to Chen *et al.* [9], switching to electric stoves or LPG can reduce harmful emissions and improve indoor air quality. These strategies are particularly important for vulnerable populations, including children, the elderly, and those with pre-existing health conditions

III. Materials and Methods

The study was conducted in Barangay Buhay Tubig, City of Bacoor, Philippines from January 2023 to April 2023. A total of 307 houses participated in the study. Respondents of this study are the occupants of the houses that were profiled and interviewed.

The Home environmental health risk assessment was of a descriptive design, and the survey method was used to produce the necessary information for the study. This study utilized a standardized questionnaire. This questionnaire was composed of two parts. The first gathered the demographic profile of the houses according to ownership, residency, number of occupants inside the house. The other parts are questionnaires that is related to home environmental health risks. The questionnaire was statistically conducted to its validity, the researcher personally administered the

questionnaire to the houses located in Barangay Buhay Na Tubig, City of Bacoor.

For valid and reliable analysis and interpretation of the data, frequency counts, percentages, means, and standard deviations were utilized.

A 3-point scale was used to determine the perception of the respondents, as shown in Table 1 below.

Table 1. The 3 point Likert scale

Unit Weight	Weighted Mean	Verbal Interpretation
3	2.34–3.0	High level concern
2	1.67–2.33	Moderate Level concern
1	1.0–1.66	Low level of concern

IV. Results and Discussion

Table 2 showed the summary of the demographic profile of the houses that were profiled in this research. Most of the houses were owned with frequency of 176 houses out of 307 houses profiled with a percentage of 57.32%. Owning a house is an important component in the demographic as it will determine if the occupants are the actual ones. owners. This is important in taking care of houses from indoor pollution compared to occupants that are just renting. The number of years was also included in the profiling as it will show the number of years occupants are staying in the house. It is important as it concerns the number of years these occupants were exposed to indoor pollution. The table showed that most residents stayed for more the 10 years with a frequency of 112 out of total number of houses profiled with a percentage of 36.48%. The number of occupants was included as it will determine the number of occupants who are exposed to the pollutants. The table showed that 53.47% are having range of 4–6 occupants.

Table 2. Summary of the demographic profile of respondents

Profile	Frequency	Percentage
Ownership Owned	176	57.32%
Not Owned	131	42.67%
Residency 0–5 years	94	30.61%
5–10 years	101	32.89%
More than 10 years	112	36.48%
No. of Occupants in the House		
1–3	101	32.89%
4–6	165	53.74%
More than 7	41	13.35%

Table 3. Health risk factor (environment)

Health Risk Factor- SOP#2 (Environment)	Mean	SD	VI
1. How far is your home from the following: Factory, Gas Station, Dry Cleaners, Auto Body Shop?	1.86	0.7	Moderately Concern
2. How many blocks is your home from a busy street or highway	1.73	1	Moderately Concern
3. Are there any unpaved roads, shoulder or driveway adjacent to the home	1.39	0.5	Low Concern
4. How often do you smell smoke from burning leaves, grass, or other sources	1.8	1.0	Moderately Concern
5. Are there any paint peeling or flaking inside or outside home?	1.66	0.9	Low Concern
Overall Average	1.68	0.8	Moderately Concern

Table 3 presents home risk factors that are associated with the environment. The houses that are near gasoline stations, roads, factory workers, etc. are exposed to the outside environmental pollutants that may enter houses. The result of this study showed that most of the items included are at a moderately concern level. Most of the houses are near gas stations, auto body shops, and laundry stores with dry cleaners. The mean answer to these questions is at 1.86 with SD of 0.7. Another item that is in the moderate level is the location of the house where mostly is near busy roads with a mean answer of 1.73 (SD1). The item which occupants can smell burning leaves was rated 1.8 mean with SD of 1.0. The burning of leaves was already banned under RA 9003 (Anti-Burning Law). These health risk factors that are related with environment adjacent to ask got a mean score of 1.68 with verbal interpretation of moderately concern level. One study by Suh *et al.* [11] found that houses located near busy roads exhibit significantly higher levels of fine particulate matter (PM2.5), which can infiltrate through cracks, gaps, and poorly sealed windows. PM2.5 is particularly concerning as it can penetrate deep into the lungs, leading to respiratory conditions such as asthma, bronchitis, and even lung cancer [11]. Moreover, Gómez *et al.* [12] identified that indoor nitrogen dioxide levels were notably higher in homes near roads due to the close proximity to vehicle emissions. Prolonged exposure to NO_2 can aggravate existing respiratory diseases and contribute to cardiovascular issues [12].

Table 4. Health risk factors (dust and lead control)

Health Risk Factor (Dust and Lead Control)	Mean	SD	Verbal Interpretation
1. Do you wash hands many times with soap and water?	1.81	1.0	Moderately Concern
2. Are your bedrooms windows open at night when sleeping?	1.55	1.0	Low Concern
3. Do you wash linens and pillowcases every week?	1.80	1.0	Moderately Concern
4. Is major heat source wood?	1.66	0.8	Low Concern
Overall Average	1.70	0.9	Moderately Concern

Health risk factors related to dust and lead are concerns among the sources of indoor pollution. Settled dust found in the unwashed linens and pillows can exacerbate respiratory illnesses inside the house. Another concern is the dust mite particularly North American Dust mite and European Dust Mite. Mites prefer relative humidity levels of 70% and 80% and temperatures in the range of 24°C to 27°C. In Table 4, washing linens and pillows was rated moderately concern with a mean of 1.80 by the respondents. Washing hands also as an effective way of removing dust and other contaminants was also rated at moderately concern (Mean = 1.81). Lead is widespread in the environment. People absorb lead from a variety of sources every day. The most source of lead exposure to children is contaminated house dust that has settled on horizontal surfaces, deteriorated lead-based paint, and drinking water from corrosion of plumbing system. The overall average for health risk factors related to dust and lead was rated moderately concerns level. One of the primary concerns with dust is its role in exacerbating respiratory conditions. According to Klaassen *et al.* [13], exposure to dust particles, especially fine particulate matter (PM2.5), has been linked to an increased incidence of asthma, Chronic Obstructive Pulmonary Disease (COPD), and other respiratory infections. Dust particles can irritate the respiratory tract and penetrate deep into the lungs, leading to

inflammation and increased sensitivity to allergens [13]. Chen *et al.* [9] further emphasized that fine dust particles contribute to long-term health risks, including cardiovascular diseases, by affecting blood vessels and increasing systemic inflammation.

Table 5. Health risk factor related to moisture

Health Risk Factor (Moisture)	Mean	SD	Verbal Interpretation
1. Do you clean the refrigerator coils and/or drip pans?	1.85	0.9	Moderately Concern
2. Are there any water leaks or damps areas in kitchen or bathrooms?	1.49	1.0	Low Concern
3. Do you use exhaust fan or bathroom windows during and after showering?	1.71	1.0	Moderately Concern
4. If you have dryer, is it vented to the outside?	1.83	1.0	Moderately Concern
5. Can you open window in each room?	1.58	1.0	Low Concern
6. Are there any bacterial odors present in your house?	1.58	1.0	Low Concern
Overall Average	1.67	1.0	Moderately Concern

Moisture is another concern in indoor pollution. These can create a variety of microorganisms, particularly the fungi that cause diseases. Common moisture sources include rain leaks (e.g., roofs and wall joints); surface ground water leaks (e.g., poorly designed or clogged rain gutters and footing drains, basement leaks); plumbing leaks, and stagnant water in appliances (e.g., dehumidifiers, dishwashers, refrigerator drip pans and condensing coils and drip pans in HVAC systems. Moisture problems can also be due to water vapor migration and condensation problems, including uneven indoor temperatures and poor air circulation. Table 5 showed the cleaning of refrigerator coils and drip pans was rated moderately concern by the respondent with mean score of 1.85. Another that was rated moderately concern was using the exhaust fan or bathroom windows during and after showering. Most of the houses profiled do not have exhaust fans or windows in the bathroom. The dryer for washing laundry was not vented outside in most of the houses profiled with a mean score of 1.83.

Table 6. Health risk factor related to indoor air quality

Health Risk Factor (Indoor Air Quality)	Mean	SD	Verbal Interpretation
1. Is your gas stove old?	1.92	1.0	Moderately Concern
2. Do you smell gas from the gas cylinder?	1.54	1.0	Low Concern
3. Do you use exhaust fan while cooking?	2.5	1.0	High Concern
4. Do you smell smoke while cooking?	2.02	1.0	Moderately Concern
Overall Average	1.99	1.0	Moderately Concern

Indoor air quality refers to the air quality within and around buildings and structures, especially it relates to the health and comfort of building occupants. Table 6 shows that most of the houses profiled do not use exhaust fan while cooking with a mean score of 2.5 with verbal interpretation of high concerns. According to WHO [1], household air pollution is generated using inefficient and polluting fuels and technologies in and around the home that contains a range of health-damaging pollutants, including small particles that penetrate deep into the lungs and enter the blood stream. In poorly ventilated dwellings, indoor smoke can have levels of fine particles 100 times higher than acceptable. In this table, most of the houses profiled have problems with indoor air quality as exhaust fans are non-existent.

Table 7. Health risk factors related to hazardous chemicals/VOCs

Health Risk Factor (Hazardous Chemical/VOC)	Mean	SD	Verbal Interpretation
1. Oil based paint, stain, varnish, thinner, stripper	1.76	1.0	Moderately
2. Spray-on adhesives, paints, or lubricants	1.66	1.0	Low
3. Rubber or contact cement, plastic glue, or epoxy	1.8	1.4	Moderately
4. Permanent markers or whiteboard markers	1.82	1.0	Moderately
5. Ammonia or chlorine-based cleaners	1.91	1.0	Moderately
6. Are chemical cleaners used extensively in your home?	1.92	1.0	Moderately
7. Has remodeling recently have been done in your home?	1.60	2.0	Low

Table 7 shows the usage of household items that are considered with volatile organic compounds. VOCs are compounds that have a high vapor pressure and low water solubility. Many VOCs are human made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. VOCs can cause health effects. In the table, most of the respondents are using chemicals with high VOCs like oil-based paints, rubber or contact cement, plastic glue, or epoxy. For cleaning materials, they are using ammonia or chlorine-based cleaners. Most of the respondents that were asked do not know the health effects of these chemicals. The overall rate of the respondents for this health risk factors is moderately concerns with a mean score of 1.80.

Table 8. Health risk factors related to hazardous chemicals/VOCs

Health Risk Factor (Hazardous Chemical/VOC)	Mean	SD	VI
8. Has individuals used pesticides, paints or solvents?	1.62	2.0	Low
9. Do you use aerosols sprays more often?	1.79	1.7	Moderately
10. Do you use mothballs and air fresheners more often?	1.78	2.0	Moderately
11. Do you pesticide in your house?	1.87	2.0	Moderately
12. Correction fluids, glues, and adhesives	1.99	2.0	Moderately
13. Carbonless copy paper, photographic solution	1.84	2.0	Moderately
14. Do you often use dry cleaned clothing?	1.68	2.0	Low
Overall Average	1.79	1.73	Moderately

Table 8 shows the other volatile organic compounds that are used by the profiled respondents. In this table, respondents used mothballs, air fresheners, correction fluids, glues, and adhesives. According to a study by Batterman *et. al.* [14], the concentrations of naphthalene in indoor environments can exceed safety limits, particularly in poorly ventilated spaces. Air fresheners, which often release VOCs such as phthalates, formaldehyde, and terpenes, are another major source of indoor air pollution. These substances can react with ozone in the air to form harmful byproducts like formaldehyde, a known carcinogen. Research by Kumar *et.*

al. [15] revealed that air fresheners significantly contribute to indoor VOC concentrations, potentially exacerbating respiratory and allergic conditions. Similarly, adhesives and glues, commonly containing chemicals like acetone, toluene, and xylene, release VOCs that can cause dizziness, cognitive impairment, and long-term damage to the nervous system.

Table 9. Health risk factors related to usage of chemicals and protection

Health Risk Factors	Mean	SD	Verbal Interpretation
1. Protection in inhaling products			
1) Nothing	1.84	2.0	Moderately
2) Use outside or wear a respirator	1.92	2.0	Moderately
3) Open a window	1.91	2.1	Moderately
4) Open at least 2 windows and use a fan	1.9	2.2	Moderately
2. Do you often used banned products (oxalic acid, acetone, toilet cleaner with danger on the level)	1.78	2.0	Moderately
3. Do you wear gloves when using them?	2.1	2.2	High
4. Do you wear goggles or glasses when using them?	1.82	2.0	Moderately
5. Are there any flammable products store near fire or heat?	1.64	2.0	Moderately
6. Are there any hazardous within reach of children	1.39	2.0	Low

Table 9 presents the protection that respondents are using when handling hazardous chemicals, most of the respondents profiled are not using gloves when using hazardous chemicals with a mean score of 2.1. With regards to using banned products like oxalic acid, acetone, toilet cleaner, it was rated by the respondents as moderately level. Even the presence of flammable products is not properly stored as it just placed near fire or heat. This table shows that most of the houses profiled are not aware of the danger of flammable materials or hazardous chemicals. Incidents of accidental ingestion of chemicals or explosions are reported due to negligence. There must be an advocacy program on the proper storage of these chemicals.

Table 10. Health risk factors related to usage, storage, and disposal of hazardous chemicals

Health Risk Factors	Mean	SD	Verbal Interpretation
7. Are there any damaged, rusting or open container?	1.34	2.0	Low
8. Are there any banned or restricted products?	1.42	2.0	Low
9. Do you often used pesticides inside the house?	1.34	2.2	Low
10. Do you label liquid products and separate storage area?	1.82	2.0	Moderately
11. Do you dispose leftover pesticides in the trashcan	2.27	2.0	High
Overall Average	1.82	2.0	Moderate

Table 10 showed the usage, storage, and disposal of hazardous chemicals, banned products in the house. In this table, the disposal of leftover pesticides was rated high with a mean of 2.27. This means that every household does not have ways to dispose of leftover hazardous chemicals, pesticides. Most of the respondents said that they dispose these chemicals in the trash bin together with other household waste. Overall, respondents rated this at moderate concern level.

V. Conclusion

Most of the houses evaluated are in the moderately level of concern especially on the proper usage of hazardous chemicals that may cause injury or diseases to the occupants of the house. In the indoor air quality, most of the respondents do not use exhaust fan or open windows while cooking. With this, it increases the air pollutants through the smoke generated while cooking. Most of the respondents used three times a week cleaning solutions like sodium hypochlorite, which in the long-term use can increase the volatile organic compounds indoors. According to American Lung Association [16], these volatile organic compounds can react with other gases and can cause cancer. These volatile organic compounds can exacerbate chronic respiratory problems, particularly those people with asthma, according to association. They even recommended not to mix bleach with ammonia because it will cause chronic breathing problems and even death. Use of protective gloves or clothing is also high for the respondents while using the chemicals. They also do not open the windows while they are cleaning. The disposal of pesticides used in the household is also a high concern. They regarded the leftover pesticides like rodenticides or even containers as ordinary waste. These leftover pesticides or containers can contribute to environmental pollutants. The labeling of chemical products was also rated moderately concerned. Some of the respondents do not have storage area for these chemicals. Some of these chemicals were flammable that have the capacity to cause fire.

Conflict of Interest

The author declares no conflict of interest.

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