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Review article

FORMALDEHYDE FIXATION BLOCKS AS A MITIGATING TOOL OF WASTE DISPOSAL

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ABSTRACT: This study focused on the product development of fixation blocks as mitigating waste disposal of formaldehyde. With the objectives of producing a proper waste disposal and alleviate the amount of formaldehyde used in Science laboratories and other scientific experiments, the researchers used cement as a stabilizer with different measurement together with the calcium containing materials such as calcium hydroxide, calcium carbonate and plaster of paris. Tests for compression and flexure were done to select the best product among the mixtures used in the study. Findings revealed that the best mixture for formaldehyde fixation block is the 25% calcium hydroxide, 75% cement and 40% formaldehyde. Based from the test of formaldehyde leachate using Colorimetric-Nash Method with reference of Japanese International Standard, for exposed and non-exposed fixation blocks, 8.84 mg/L (ppm) for exposed set-up and 7.38 mg/L (ppm). The range of formaldehyde leachate is moderate level only and within the range of 5 to 20 mg/L(ppm). Furthermore, test of formaldehyde leachate identified the calcium hydroxide is the best binder of formaldehyde among the given components of mixtures used in the study. With this, formaldehyde fixation block is considered as the best mitigating tool for hazardous waste disposal such as formaldehyde.
Keywords: Compression; Flexure; Formaldehyde; Leachate

INTRODUCTION

Science laboratories, investigations and activities serve as one of the significant requirements for learners who are taking up Science subjects particularly in the field of Biology. Experiments such as taxidermy and specimen preservation are the common activities where in formalin are being use. Formaldehyde is an organic compound used as disinfectant, biocide, tissue fixative and embalming agent, drug testing, photography and other important usage in industries. Formaldehyde is predominantly use in agriculture, concrete and plaster additives, cosmetics, disinfectants, photography and wood preservation. This organic compound is tagged by US National Toxicology in 2011 as the human carcinogen.

In the present situation, there is no proper waste disposal of chemicals and other trashes which are used in various scientific experiments and laboratory procedures in the University. Most Biology students collected all used chemicals particularly formaldehyde for stock or throw it directly in the sinks of laboratory rooms. Throwing of chemicals such as formaldehyde may have some adverse effects in the long run not only in human but on water system and environmental condition of the University.

This study seeks possible answers or solutions on the conceivable proper waste disposal of hazardous chemicals such as formalin being used in the University. With the deteriorating environmental conditions, there must be feasible ways on how to manage and dispose hazardous chemicals.

Aside from its ecological study, researchers came up with a product development and discovery which may help the University to produce a simple proper waste disposal of hazardous chemicals.

Statement of the Problem

It has been identified that one of the major problems in schools and Universities which are offering Science Courses with Laboratory activities and experiments have the demands of using hazardous chemicals such as formaldehyde which has detrimental effect to human health as well as environmental condition.

Specifically, this study sought to answer the following questions.

1. What is the best developed formaldehyde paving block in terms of compression and flexure with the combination of the materials below?

A.

a.100% cement, 0% plaster of paris, 40% formaldehyde

b.75% cement, 25% plaster of paris, 40% formaldehyde

c.50% cement, 50% plaster of paris, 40% formaldehyde

d.25% cement, 75% plaster of paris and 40% formaldehyde

e.0% cement, 100% calcium hydroxide, 40% formaldehyde

B.

a.100% cement, 0% calcium hydroxide, 40% formaldehyde

b.75% cement, 25% calcium hydroxide, 40% formaldehyde

c.50% cement, 50% calcium hydroxide, 40% formaldehyde

d.25% cement, 75% calcium hydroxide, and 40% formaldehyde

e.0% cement, 100% calcium hydroxide, 40% formaldehyde

C.

a. Ca.100% cement, 0% calcium carbonate, 40% formaldehyde

b.75% cement, 25% calcium carbonate, 40% formaldehyde

c.50% cement, 50% calcium carbonate, 40% formaldehyde

d.25% cement, 75% calcium carbonate, and 40% formaldehyde

e.0% cement, 100% calcium carbonate, 40% formaldehyde

D.

100% cement, 0% of any binder, 40% formaldehyde *another 2 sets were prepared for 30% formaldehyde and 20% formaldehyde.

2. Comparing the amount of formaldehyde leachate from the various mixtures of components given, which has the least and the most amount of formaldehyde leachate present in each?

3. What is the best paving block as a mitigating tool of waste disposal such as formaldehyde?

4. What is the relevance of the study in designing and developing disposal of wastes and toxic chemicals for the University framework?

Significance of the Study

This research study on the Formaldehyde Fixation as a Mitigating Tool of Waste Disposal is significant for the following reasons:

By producing the formaldehyde fixation blocks, this will serve as a proper waste disposal for hazardous chemical such as formaldehyde. The result of this study will serve as a guide for other ecologists and environmentalists to come up with other hazardous waste disposal ways particularly in the needs of the learners. This product development may provide solution to further mitigate the usage of formaldehyde in various laboratory experiments. This research study will be able to come up with different proper waste disposal ways on schools, colleges and universities in Manila and other cities and regions of the country to address the issue on the proper uses of hazardous chemicals.

The impact of this science product development will lead to ecological and environmental improvement and eventually to regional and national growth and be patented to be used regionally and nationally.

Theoretical Framework

Most Universities and schools in the Philippines offer various courses which are inclined to Sciences. Scientific fields such as Biology which is using various chemicals which play an important role in fixation, preservation and staining purposes. One of the common chemical being used by Biology students and educators is the formalin. Formaldehyde (HCHO) is a gas (available as a 37% concentrated solution, stabilized with methanol). The 10% dilution (approximately 4% formaldehyde) has been used as a fixative since the end of the 19th century. Formalin is the addition of methyl alcohol and formaldehyde. There are numerous uses of formalin for preservation of fish. Not only fish preservation, formalin is being used for embalming techniques in most science laboratories and experiments such in the field of human pathology, zoology. Histology and other related fields. Formaldehyde is very useful in the industries due to its potential precursor of other components such as textile industry. This chemical is also being use as disinfectant and germicide. For medical purposes, formalin is also useful for wart treatment. With the tremendous uses of formaldehyde, it serves its significance to the various fields.

According to Environmental Protection Agency in 2007, formaldehyde is a colorless flammable gas which has a pungent odor and highly reactive to other substances. Most industries are using formaldehyde such as in cigarette companies, cosmetic products, nail hardeners, and some cleaning products.

Some hospitals, universities and other industrial areas are using formaldehyde for embalming specimens, and for other laboratory experiments. However there are existing protocols in handling formaldehyde. One of these policies is the regular monitoring on formaldehyde exposure, and other usages of formaldehyde for appropriate engineering controls, and the culture of professional laboratory work can help to employ formalin, the ubiquitous fixative in anatomical pathology, without harmful effects [1]. Based from Occupational Safety and Health Administration in 1993 [2], used formaldehyde either from spill or generated from process such as laboratory activities must be stored in a properly labelled hazardous waste and not subject to heat cycles and with a well-ventilated area. There is the use of generators to be facilitated by expert in the field for the proper disposal and to regulate the waste. Other way of disposing formaldehyde is to place it on vessels for storage purposes. In other method, NBF or neutral buffered formalin or the formalex green to neutralize the amount of formaldehyde present in the mixture.

Other companies are using other fixatives or chemicals for embalming and preserving specimens instead of formaldehyde. In other countries such as US like in Minnesota with its Technical Assistance Program in 2009 [3], formaldehyde recycling is being use where in 80-90% of the formalin is being recovered by distillation (Figure 1).

Conceptual Framework

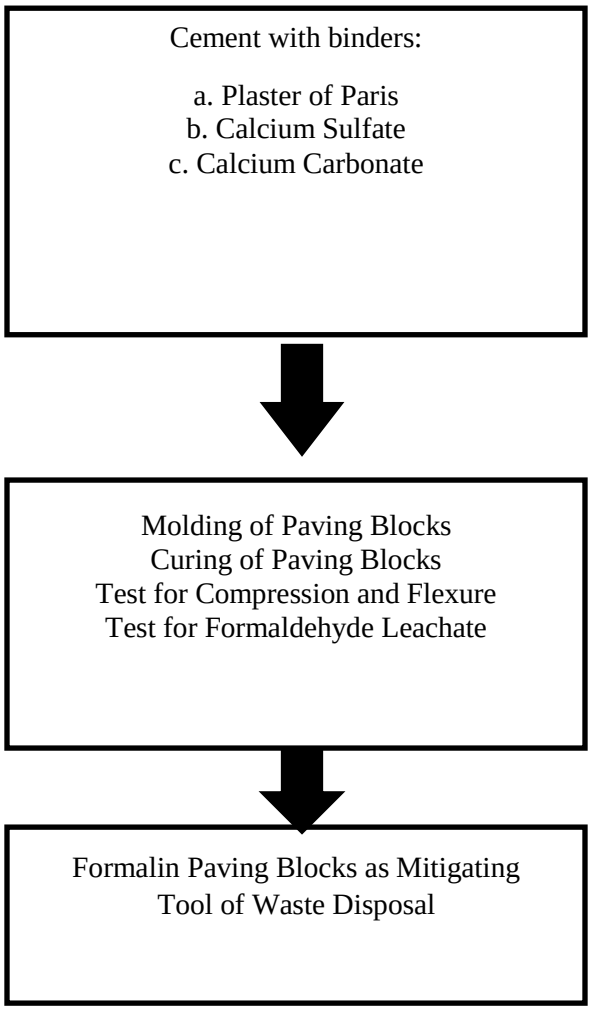

Figure 1: Conceptual Framework of the Study.

Literature Review

Formaldehyde is a common chemical used for cadaver and other structural preservations in most science laboratories and studies. Formaldehyde is also known as Formalin, Formol, Formic Aldehyde, Methanal, Oxomethane and Oxymethylene (Chemfinder). According to Material Safety Data Sheet in 2005, formaldehyde consists of 30 to 40% formaldehyde, 5 to 15% methanol and water. Based from Weigl, there are some sources of formaldehyde which are naturally found such as 22 parts per million of formaldehyde in apple, there is 20 parts per million in pork, about 3.3 parts per million is found in cow's milk and 20 parts per million in fish from salt water. Other sources of formaldehyde are painting with 968 parts per billion, wallpaper with 2051 parts per billion, gas

range in self-made mode with 337 parts per billion, electric range in self-clean mode with 183 parts per billion, one cigarette in small room with 49 parts per billion. Another source is the comparison between urban airs with 5 to 100 parts per billion while there is 0.8 to 5 parts per billion found in rural air.

Most hospitals, schools, universities and industries are using and dependent on formaldehyde. There are several side effects in the tremendous use of formaldehyde. Most consumer products are containing formaldehyde such as antiseptics and cleaning agents, carpets and permanent press fabrics, cosmetics, fertilizers, insulation of electrical uses such as wiring and appliances, medicines, vitamins, varnishes and preserved foods [4].

With the tremendous use of formaldehyde, awareness on its negative effect particularly to human must be given priority. Based from Material Safety Data Sheet, formaldehyde has potential acute health effects such as hazardous to eyes and skin which may be corrosive and irritant. It has also the potential chronic health effects such as formaldehyde has carcinogenic effects or mutagenic effects to human. As mentioned in the Public Health Statement of Ref. [4], formaldehyde enter the human body is through inhalation, or when you breathe air containing formaldehyde which affects the cell lining of respiratory tract. Ingestion may also the process on how formaldehyde enters the human body. Other effects of formaldehyde are bronchitis, pneumonia, gastritis, peritonitis, myositis and chronic poisoning.

Based from the typical exposure and range of the amount of formaldehyde, Safety Directory Factsheet of 2004 identified that 0.1 to 5 parts per million or milligram per liter is low exposure level, 5 to 20 ppm or mg/L is the level for moderate level of formaldehyde and 20 to 100 ppm or mg/L is considered as the high level of formaldehyde content.

Other hazardous wastes like heavy metals are disposing by cement-based materials. Cement based materials is used for stabilizing metal sludge with the components of heavy metals such as the concertation of zinc, chromium and lead [5]. Another study was conducted by Ref. [6] in which the study used ashes as agent for cement-lime based stabilization of hazardous wastes. Another study is the fixation of heavy metals in geopolymeric materials based on brown coal fly ash for mitigating heavy metals like zinc, copper, chromium, cadmium and lead [7]. With the hazardous effects of formaldehyde, the study developed mitigating tool with the use of cement –based stabilization together with calcium carbonate, calcium hydroxide and plaster of paris as binders which may lessen the amount of formaldehyde particularly to test the formaldehyde leachate present.

METHODOLOGY

This study is an experimental research and a development research. It involved molding, curing and testing of compression, flexure and presence of formaldehyde leachate.

The research study was conducted at Technological University of the Philippines, under CEMD, IRTC. Collection and purchase of cement, calcium carbonate, calcium hydroxide, plaster of Paris and formaldehyde. Mixtures of the following components were combined: 100% cement, 0% plaster of paris, 40% formaldehyde, 75% cement, 25% plaster of paris, 40% formaldehyde, 50% cement, 50% plaster of paris, 40% formaldehyde, 25% cement, 75% plaster of paris and 40% formaldehyde, 0% cement, 100% calcium hydroxide, 40% formaldehyde, 100% cement, 0% calcium hydroxide, 40% formaldehyde, 75% cement, 25% calcium hydroxide, 40%, formaldehyde, 50% cement, 50% calcium hydroxide, 40% formaldehyde, 25% cement, 75% calcium hydroxide and 40% formaldehyde, 0% cement, 100% calcium hydroxide, 40% formaldehyde, 100% cement, 0% calcium carbonate, 40% formaldehyde, 75% cement, 25% calcium carbonate, 40% formaldehyde, 50% cement, 50% calcium carbonate, 40% formaldehyde, 25% cement, 75% calcium carbonate, and 40% formaldehyde, 0% cement, 100% calcium carbonate, 40% formaldehyde, 100% cement, 0% of any binder, 40% formaldehyde. Water was first used as the part for the paving blocks and replaced by the amount of formaldehyde ranged from 40%, 30% and 20%. There were 360 pieces of paving blocks.

Each paving block measured 100 mm × 53 mm × 200 mm, which is the common size which is available commercially. All 360 pieces of paving blocks were molded and cured for 28 days. After curing, test for compression and flexure were done. Testing compression and flexure of developed paving blocks used Universal Testing Machine and Compression Machine with 10 tons Capacity. Best products were selected through compression and flexure from 360 pieces of paving blocks. After selecting the best product of paving blocks, water was substituted by formaldehyde with corresponding 40%, 30% and 20%.

Best products of paving blocks were divided into two set-ups. Each block was placed for every sealed container. One group was placed in a closed container submerged to water for 28 days after producing the paving blocks and the other group of paving blocks were exposed in the air for 28 days and place in a container and submerged to water for another 28 days. Every one liter of water from each container underwent to test of formaldehyde leachate in Intertek Testing Services Philippines, Inc., located in 2307 Chino Roces Extension, Makati City Metro Manila, Philippines [8-10].

RESULTS AND DISCUSSION

Based from the given mixture of cement, calcium carbonate, calcium hydroxide, plaster of paris with 40% formaldehyde, 30% formaldehyde and 20% formaldehyde, best product of paving blocks with the following mixtures: 100% cement and 40% formalin, 75% cement, 25% calcium hydroxide and 40% formalin, 75% cement, 25% calcium carbonate and 40% formaldehyde and 100% plaster of paris and 30% formaldehyde.

Best product of paving blocks were the following mixtures: 100% cement and 40% formalin, 75% cement, 25% calcium hydroxide and 40% formalin, 75% cement, 25% calcium carbonate and 40% formaldehyde and 100% plaster of paris and 30% formaldehyde. All the best products underwent to test of leachate as formaldehyde.

Table 1: Presents the results of formaldehyde leachate.

Mixtures	**Exposed (28 days exposed, 28 days submerged to water) mg/L (ppm)**	**Non-Exposed (directly submerged to water for 28 days) mg/L (ppm)**
Cement (Control) 100% cement+40% formaldehyde	10.43	8.60
25% Calcium Hydroxide+75% Cement+40% Formaldehyde	8.84	7.38
25% Calcium Carbonate+75% Cement+40% Formaldehyde	35.97	12.53
100% Plaster of Paris+30% Formaldehyde	29,532	253,737

Data of Table 1 revealed that the amount of formaldehyde leachate present in best product paving blocks were as followed: Calcium Hydroxide in both exposed and non-exposed measured 7.38 and 8.84 mg/L respectively. It was followed by the control set-up with cement with 8.60 and 10.43 mg/L. The third mixtures are Calcium Carbonate with 12.53 and 35.97 mg/L formaldehyde leachate. Plaster of Paris has the level of formaldehyde leachate with 253,737 and 29,532 mg/L.

Summary of Findings

From the data gathered, the following findings are summarized:

1. Among the various mixtures combined, the best formaldehyde paving blocks in terms of compression and flexure are 100% cement and 40% formalin, 75% cement, 25% calcium hydroxide and 40% formalin, 75% cement, 25% calcium carbonate and 40% formaldehyde and 100% plaster of paris and 30% formaldehyde. All the best products underwent to test of leachate as formaldehyde.

2. Using the Colometric-Nash Method of Japanese International Standard L 1041/1096, mixture of 25%calcium hydroxide, 75% cement and 40% formaldehyde with formaldehyde leachate of 7.38 mg/L in non-exposed for 28 days followed by 28 days submerge in water while in exposed paving blocks is 8.84 mg/L. Cement as the control has 10.43 mg/L in exposed paving block and 8.60 mg/L in non-exposed paving block. In 25% Calcium Carbonate+75% Cement+40% Formaldehyde, exposed paving block has 35.97 mg/L formaldehyde leachate and 12.53 mg/L formaldehyde leachate. The most formaldehyde leachate is found in 100% plaster of paris and 30% formaldehyde with the range of 29,532 mg/L formaldehyde leachate in exposed condition and 253,737 mg/L in non-exposed condition.

3. Based from the test of formaldehyde leachate, mixture with 25% calcium hydroxide, 75% cement and 40% formaldehyde in exposed and non-exposed condition gives the least amount or level of formaldehyde leachate with 8.84 mg/L and 7.38 mg/L.

4. Formaldehyde paving block is designed and developed as a mitigating tool for the waste disposal of wastes and toxic chemicals for Biology major students who are dependent in using formaldehyde in the field.

CONCLUSIONS

From the above findings, the following conclusions are drawn:

1. In the test of compression and flexure for paving blocks, various mixtures combined, the best formaldehyde paving blocks in terms of compression and flexure are 100% cement and 40% formalin, 75% cement, 25% calcium hydroxide and 40% formalin, 75% cement, 25% calcium carbonate and 40% formaldehyde and 100% plaster of paris and 30% formaldehyde. All the best products underwent to test of leachate as formaldehyde.

2. Leachate is any form of any liquid which is passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed. Among the given mixtures and best formaldehyde paving blocks, the least amount of formaldehyde leachate was produced from calcium hydroxide in both exposed and non-exposed method followed by the cement as the control with the greater amount of formaldehyde leachate

then followed by calcium carbonate and the most amount of formaldehyde leachate is from the presence of plaster of paris.

3. The best formaldehyde paving block as mitigating tool as waste disposal is the use of calcium hydroxide which has the capacity to absorb or bind the amount of formaldehyde combined in the mixture. Based from the safety directory of range or measurement in milligram per Liter or parts per million, the range of 5 to 20 ppm formaldehyde has a moderate level as the mixture with calcium hydroxide read is within the range of 5 to 20 ppm. There is a small amount of formaldehyde leachate released in water with the 8.84 mg/L and 7.38 mg/L.

4. This study is relevant in product development for mitigating the amount of formaldehyde which is normally used by Biology major students in universities. Paving blocks can also be used for hard surface for ground such as in driveways, patios or any area in which there is need for concrete paving blocks.

RECOMMENDATIONS

1. To increase the awareness of the students, educators and other stakeholders of the University on the hazardous and detrimental effect of formaldehyde in human health and environmental condition.
2. Come up with substitute substance of formaldehyde for preservation, embalming and other significant processes involve in laboratory experiments in the University.
3. The faculty together with the person in charge must ensures the proper handling of hazardous wastes used by the students such as formaldehyde and other toxic chemicals which are normally used by the students.

REFERENCES

[1] Dimenstein I (2009) A Pragmatic Approach to Formalin Safety in Anatomical Pathology, LabMedicine, Loyola University, Chicago Medical Center, Illinois, USA 40: 740-746.

[2] Occupational Safety and Health Administration (2011) OSHA Factsheet. Accessed on: April 2, 2014 from www.osha.gov

[3] Minnesota Technical Assistance Program (2009) Formalin Recycling in Health Care Lab. Accessed on: May 1, 2014 from www.mntap.umn.edu

[4] Agency for Toxic Substance and Disease Registry (2008) Public Health Statement. Accessed on: July 8, 2014 from www.atsdr.cdc.gov

[5] Swaminathan C (2005) Leaching of Metals on Stabilization of Metal Sludge Using Cement-Based Materials, National Environmental Engineering Research Institute. Journal of Environmental Sciences 17: 115-118.

[6] Lyckova B, Huda V (2008) Ashes as an Agent for Cement-Lime Based Solidification/Stabilization of the Hazardous Wastes. GESTA 20: 91-96.

[7] Minarikova M, Skvara F (2006) Fixation of Heavy Metals in Geopolymeric Material Based on Brown Coal Fly Ash. Institute of Chemical Technology, Prague 50: 200-207.

[8] American Master Technology (2011) Formalex Green Formaldehyde Waste Treatment and Disposal System. Accessed on: June 3, 2014 from www.americanmaster.com/INSTRUCTIONS.CUFX.PDF

[9] International Agency for Research on Cancer (2004) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Accessed from: http://monographs.iarc.fr/ENG/MONOGRAPHS/vol88/index.php

[10] Maijaha A, Forsman J, Lahtinen P, Leparren M, Helland A, et al. (2006) Cement Stabilization and Solidification Review of Technology Norcem, Finland.


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