Hydrilla of the UNIMAS Lakes: An Ash Glaze Composition

Shamsu Mohamad
Universiti Sains Malaysia

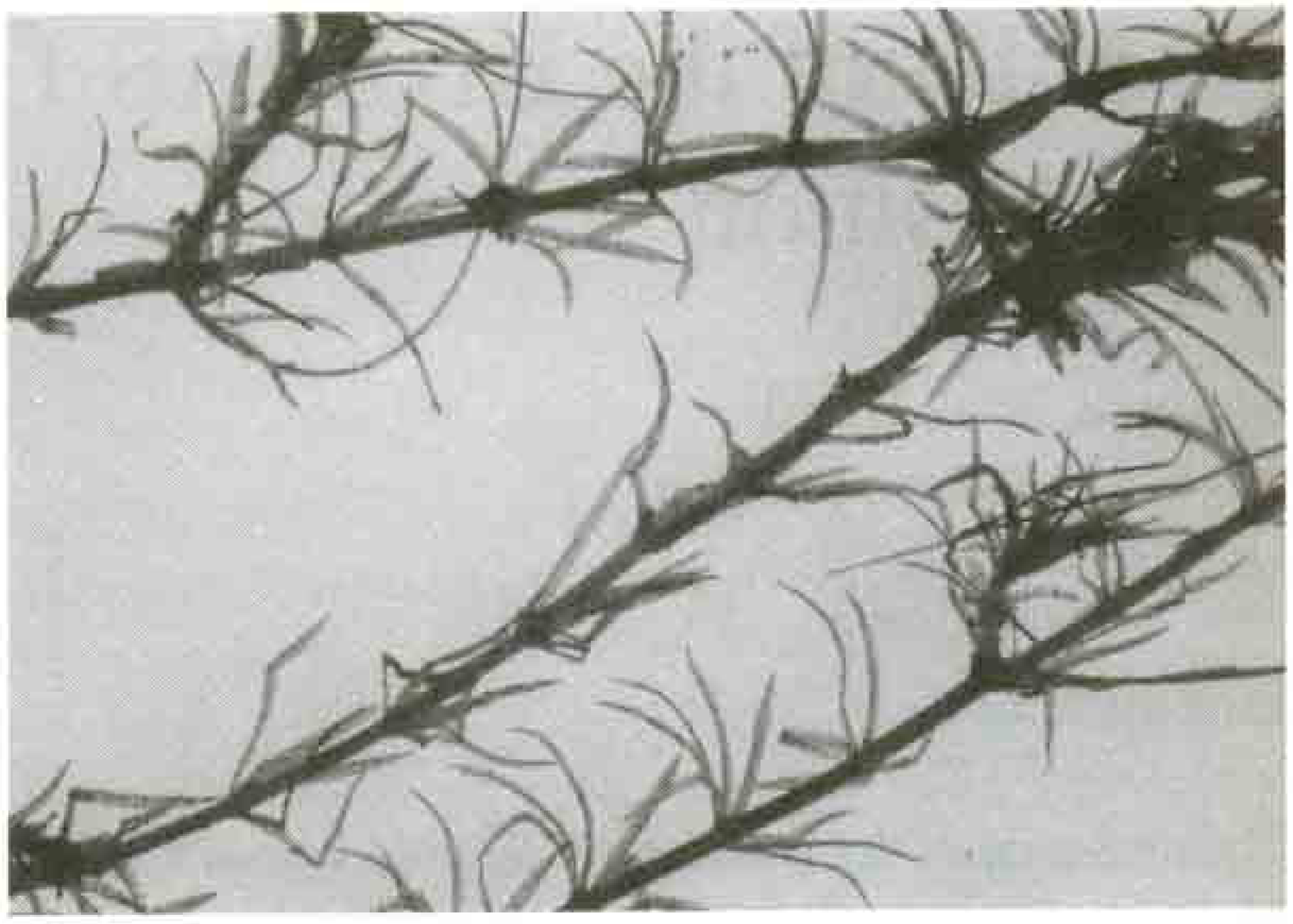
Introduction

The presence of the fresh water aquatic weeds known as *Hydrilla verticillata* in the Universiti Malaysia Sarawak (UNIMAS) lakes drew the researcher to investigate their composition for possible use in ceramics. A 'quick and dirty experiment' soon followed and it was discovered that glaze characteristics are indeed evident in these aquatic weeds. They are glassy, not porous and have colors. This discovery led me to carry out further investigation on identifying the potential of the weeds for use in the ceramics industry.

I was frequently asked to explain the reasons for choosing the aquatic weeds over other available plants like grass, yam and coconut. Apart from the results shown from the experiment above, the other primary reason is the fact that the weeds thrive and are easily found in fresh water locations like lakes, watercourse and swamp.

According to A.H. Pieterse (1990: 3), a senior ecologist at the Royal Tropical Institute of Amsterdam, weeds are plants, which are of no use to humankind in the place they thrive. Humankind here refers to the people managing the area in which the weeds are found. The above definition is also applicable to the aquatic weeds, which are perceived by humans as causing negative effects to their socio-economic activities.

Although ash glaze is not new, research on the use of the hydrilla weeds as glaze composition, has never been carried out in Malaysia or in other parts of the world. Local researchers, however, have carried out studies on glaze composition on plants like paddy, grass, rubber wood and fir leaves. Trees like pine, apple, birch, walnut, oak and willow have also been analyzed for their potential as plant ash glaze by researchers.



Hydrilla verticillata

I am of the opinion that plants found in the environment closest to humankind must be explored and studied to discover their possible use and value, particularly the plants that can be found in abundance, thrive easily and can be obtained without any cost incurred. It is hoped that the findings of this study on the hydrilla weeds would be of benefit to the students who are taking ceramic courses and would also inspire them to use the plants from their environment for future research on ceramics. The equipment required for glaze preparation is also cheap and can easily be obtained from any hardware store.

It is interesting to note that the ceramics artist, Phil Rogers (1991: 8), wrote that Katherine Pleydell-Bouverie, a former student of Bernard Leach (a famous studio artist from United Kingdom), studied various plants that grew in the lawn of her ceramics workshop in Coleshill. Katherine claims that it is more cost effective when the plants used for study are accessible for free.

It is unfortunate that plant ash glaze is not as popularly used as other commercial glaze such as transparent, satin, tenmoku, crystal and others. A primary reason for this is that plant ash glaze has a higher melting point (from 1280 ^{0}C to 1300 ^{0}C). By comparison, the melting point of commercial glaze is only 1000 ^{0}C. When the melting point is high, the cost of production goes up. Plant ash glaze is also not popular among ceramics artists as the process of producing ash glaze is tedious. It is also difficult to get regular supplies of the same species of plant over an extended period of time. Ceramics artists who are keen in using the plant ash glaze have to produce it themselves, as the plant ash is not sold in the market. Some local artists also lack the knowledge of producing formulae required for processing ash glaze. This is especially since Malay pottery such as *Labu Sayong* of Perak, *Terenang* of Pahang and *Mambang* of Kelantan do not use glaze.

This study provides a guide to students and manufacturers of ceramics on how to produce a good and consistent ash glaze formula. The *Hydrilla verticillata* weeds have great potential to be used as an ash glaze ingredient in the ceramics industry especially if commercial companies can supply ash from the weeds for the use of ceramics artists.

Aquatic Weeds of the UNIMAS Lakes

Hydrilla verticillata is an exotic aquatic weed, which originated from tropical countries like the Southeast Asian countries. However, it can now be found in Europe, Africa, Australia as well as America. The weed can grow an inch a day in an environment that is exposed to bright sunlight.

The actual date when the hydrilla weeds began to grow in the UNIMAS' lake is not known. However, random analysis suggests that they probably have been there since 1996, first at A Lake, which is next to the UNIMAS main entrance, spreading to B Lake on the right side of the chancellory building, and finally to C Lake on its left side. Various attempts have been made to eradicate the hydrilla invasion but these efforts have been futile.

Such attempts involved the use of excavators, a sampan, and a raft to heave the hydrilla out of the water. Manual labour was also called in and a number of men worked at plucking out the weeds from the lake. As indicated earlier, all these efforts were unsuccessful, and within a few months the hydrilla weeds resurfaced in the UNIMAS lakes.

The UNIMAS lakes are conducive for the growth of hydrilla weeds as various sewage such as food waste, human faeces and chemical waste from the Medical and Resource Science laboratories, found in the lakes provide nutrients for the weeds. The nutrients in the water become the primary source for the hydrilla's growth and fertility. Despite the fact that the amount of the nutrient carbon, nitrogent and phosphorus is limited, the tissue of the hydrilla which consists of 90% water, enables it to grow in the lake.

According to Siti Azamah Haji Mustapha, an officer in the Fresh Water Fisheries Research Centre in Malacca, hydrilla weeds are found in abundance in the fresh water ponds as a result of excessive pond fertilizing, and high amounts of fish food and faeces. This indicates that the water factor, particularly one with excessive nutrient content, actually contributes to the productivity and fertility of the hydrilla weeds.

Compared to the other weeds, the process of photosynthesis in hydrilla weeds normally takes place in the morning when there is very little sunlight. Nonetheless, hydrilla is capable of competing and conquering other weeds for space and growth. In fact, hydrilla was found living as deep as 15 metres below the surface of Crystal River and approximately three metres below the surface of Florida Lake in the United States of America. The hydrilla weeds are capable of reproducing at a fast rate and at the same time maintain its size via four means, namely fragmentation, tubers, turions and seeds.

Collecting Hydrilla

The growth of hydrilla in abundance in lakes has inadvertently created some problems such as the obstruction or blockage of water flow to nearby canals, thus resulting in flooding or damage to lakeside areas. The weeds also disrupt recreational activities like canoeing, boating, jet skiing, fishing and swimming.

Apart from the negative effects, the hydrilla weeds can also be beneficial to humans. Because of its biological structure, the hydrilla weeds are known to have the ability to cleanse the grimy water in the pond. Vitarich Food Inc., a health food manufacturing company in the United States uses the hydrilla as a type of fresh water herb. The weeds contain nutrients which are effective for building the body, boosting energy, reducing stress and curing problematic skin and age related illnesses. A study carried out by a researcher at the University of Florida on hydrilla herbs has shown that they accelerate the production of cow's milk and chicken eggs.

Plant Ash Glaze

Glaze can be defined as a glassy layer on clay, which has undergone a high heating process. The Dictionary of Science and Technology (1974) refers to glaze as a glassy-surface, which shines on tiles, bricks, etc. Glaze, like clothes on human body, has various shapes and functions. A glaze covered clay, is clean, has a smooth surface and has a variety of colors and textures.

The oldest type of plant ash glaze is wood ash glaze. It was discovered during the Shang Dynasty (1500 B.C) when the first kiln used wood as fuel. The glaze was produced by accident when the ash from burning wood landed on ceramic products, thus making the latter look glossy and shining. At a temperature of 1170 ^{0}C, the ash produced was considered to be of high quality. It was discovered that the type of wood used for burning and the length of time it took for the burning also determined the quality of the glaze. The thin layer of ash, which produces lesser surface shine on ceramics, is known as patina.

Plant ash glaze is produced from organic materials through the process of burning. The most commonly used materials are big bulky trees. Nonetheless, other plants like grass, hay and vegetables can also be used as glaze composition. To obtain a continuous supply of ash glaze from an identified species is actually difficult, and this has resulted in the use of ash glaze from a variety of species, which in turn affects the quality of the glaze products. Furthermore, plant ashes are not commercially sold in the market as glaze products.

Plant ashes like trees, grass and vegetables are flux agents in the glaze. Flux is a material that can reduce the temperature of silica and alumina in the glaze composition. Vegetable ashes contain alkaline flux like potash, limestone, manganese, stabilizer like silica, alumina and phosphoric acid, as well as colored material like steel. According to Bernard Leach, the elements required in glaze making are flux agents and these include lead, borax, soda, salt, limestone, magnesium and wood ash.

Certain ashes with high contents of flux can melt at a temperature of 1150 ^{0}C. There are also certain types of ashes, which have a high content of silica that makes the glaze surface dry and rough. Stabilizers such as alumina need to be added to the plant ashes so that they can melt at an estimated temperature of 1250 ^{0}C. If the dry effect is produced, a bit of flux like feldspar or terracotta needs to be added in order to produce a good glaze foundation.

Phil Rogers adds that ash glaze from different species of plants can produce different results. To a certain extent, variety in the results actually provides more satisfaction to the ceramic makers. As pointed out by Katherine Pleydell-Bouverie, plant ashes result in textures that are interesting, unique and beautiful. Nonetheless, most of the time, such effects are the results of pure chance or luck.

However, Gerlach Baas, a Dutch ceramic studio artist, is of the opinion that differences in the glaze products should be expected, as the kilns used are different. Apart from that, it should also be noted that the various plants and materials used for making ash glaze come from different areas and states. Therefore, before engaging in large-scale glaze making, it is advised that a small-scale experiment be conducted to determine the quality of the glaze. This could save time, raw materials and electrical supply especially if the outcome is not as expected.

The Process of Making Hydrilla Ash Glaze

To carry out an experiment on hydrilla ash as glaze, twenty sacks of the hydrilla weed has to be collected and dried before use. Under fine, sunny weather, the drying process takes at least three days, and the hydrilla needs to be turned over every once in a while to ensure that it gets dried completely and evenly.

The dried hydrilla weeds are then placed in a bitumen barrel which has small holes made in the wall of the barrel for the burning process. The ashes have to cool down before being moved into a container or pail of water.

The weeds which are not completely burnt which float on the water need to be discarded. The ash sedimentation can be found at the base of the pail. To get to the ashes, the remaining water in the pail is emptied. As the water can cause skin irritation due to its caustic nature, suitable gloves have to be worn to clean up the ashes.

The ash water is then filtered using a thin 80 mesh filter. The ashes that have been filtered are then dried before they can be used. The hydrilla ashes must be kept in a closed container and labeled.

Hydrilla Ash Glaze on Clay Test Pieces

White clay or white earthenware is employed in the hydrilla ash glaze experiment. The sample clay is made into two shapes – a semi-circle and a square. Both shapes are used to measure the glaze liquidity and stability. The clay is then left to dry before the biscuit firing at 1200 ^{0}C takes place.

The glaze formula which uses the hydrilla ash composition and other raw materials are mixed with a little bit of water. Other minerals added act either as flux agents (feldspar, dolomite, whiting), stabilizers (alumina) or glassy materials (silica) depending on the suitability of temperature. The processing of these minerals need to comply with the standards or grades set for the production of industrial chemical materials. The ash glaze which should not be too diluted or too thick is brushed on the biscuit clay using a soft brush. An electric kiln is used to fire the experimental sample. To find out the maturity level of a good glaze formula, two different temperatures – 1200 ^{0}C and 1250 ^{0}C – are used.

Determining the Chemical Content and Colouring Agents of the Hydrilla Weed Ash

The weight of the hydrilla weed is reduced from the original 1000 g to 83.4 g after drying and a mere 19.3 g after it has been processed. This clearly indicates that the hydrilla tissue contains 90% water.

An hydrilla ash sample sent to the Ceramics Department, SIRIM, in Shah Alam for chemical analysis using the XRF method, shows the presence of the following chemicals:

Fig. 1: Chemical content of Hydrilla

Chemicals	Chemical Formula	%
Chromium Oxide	Cr_2O_3	20.5253
Red Iron Oxide	Fe_2O_3	71.5087
Nickel Oxide	NiO	7.1274
Copper Oxide	CuO	0.7563
Zinc Oxide	ZnO	0.0613
Vanadium Pentoxide	V_2O_5	0.0141

The hydrilla ash has a high 71.5087 % content of iron oxide which acts both as flux and brown colour in the glaze technology. The percentage of chromium oxide is 20.5253%, and this chemical replaces copper as a green colored substance. Chromium produces a normal green color in glaze preparation, but will turn to nasturium red in low burning temperature if the glaze contains plumbum. Chromium is also a stable oxide and does not dissolve in water. It will, however, do so in a glaze composition that contains a high alkaline content.

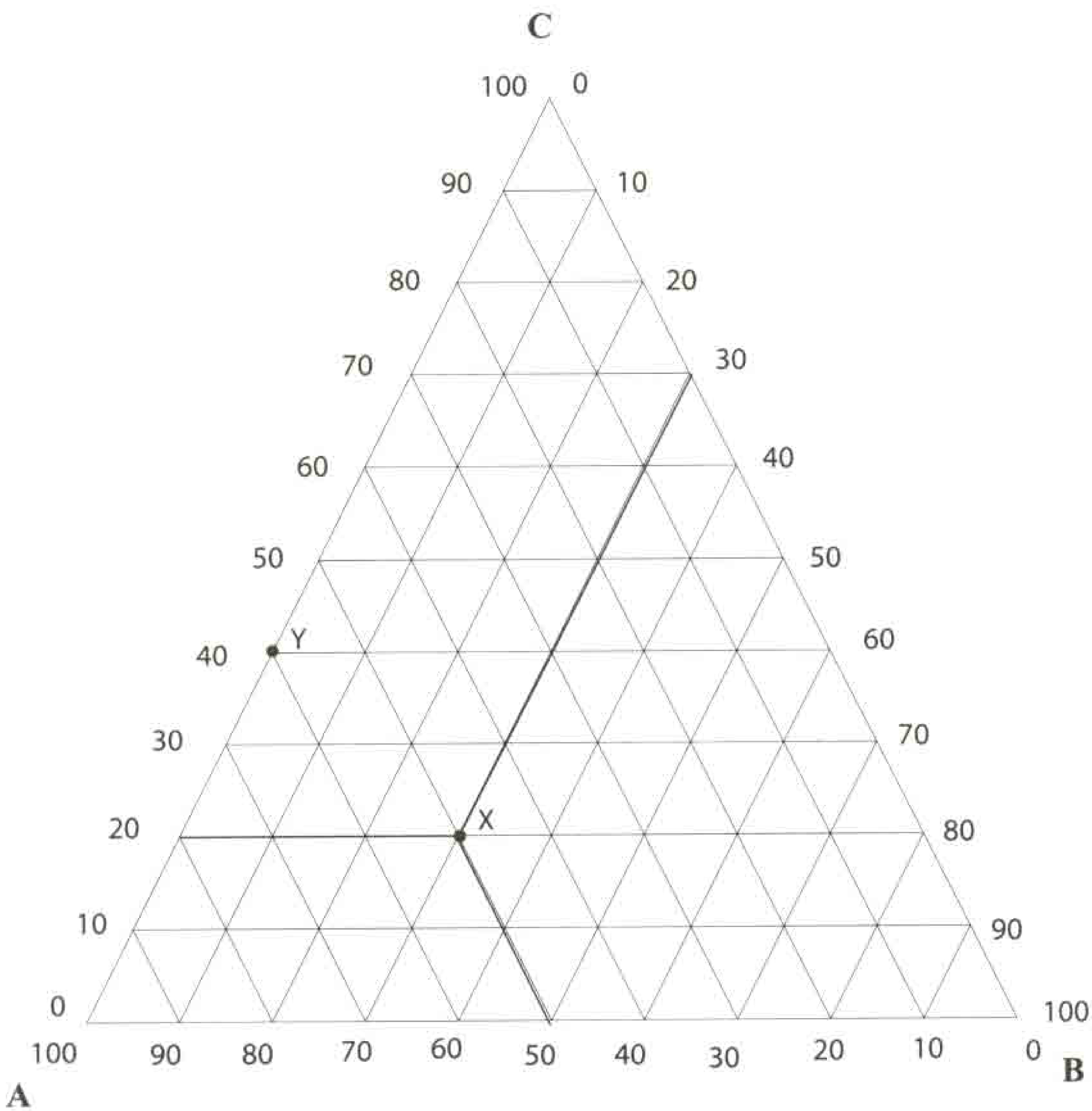
The percentage of nickel oxide is 7.1274% and this chemical acts as an agent for colors ranging from yellow to dark orange, green to blue or gray, depending on the particular glaze formula. The percentage of copper is 0.7563% and it is the strongest coloring agent. The percentage of zinc oxide is 0.0613% and it acts as a flux agent and a pacifier. Finally, the percentage of vanadium oxide is 0.0141% and it also acts as a flux agent and an agent for colors between yellow and dark orange.

Experiments on the Coloring Value in the Hydrilla Ash Glaze

When used as a sole experiment material, the hydrilla ash produces a glassy layer, which is light yellowish in color. The burning temperature at 1200 ^{0}C produces a glaze surface which is smooth and glassy which does not shine. At a temperature of 1250 ^{0}C, the glaze surface is glossier and has brighter colors.

To diversify the colors in the hydrilla ash glaze experiment, the researcher has chosen a few coloring values. The outcome of the mixture of the coloring values is a fascinating range of colors for ceramic products. Among the values used are cobalt, copper, manganese and ferum.

Fig. 2: Tri-axial blending method



Formulating the Hydrilla Ash Glaze Formula Using the Tri-axial Blending Method

The tri-axial method is used as there are only three substances required in formulating the glaze formula. The tri-axial diagram, which is triangular in shape, has a number of small-sized triangles. Each point where the lines meet represents the combination of three substances amounting to a total of 100% of the mixture. In this experiment, the hydrilla ash is frequently used in large amounts to produce the glaze formula.

The triangular lines from the bottom, starting with point A to point B, refer to area A. The digits 0 till 100 are calculated from point B to A.

The triangular lines from the right side, starting with point B to point C, refer to area B. The digits 0 till 100 are calculated from point C to B.

Meanwhile, the triangular lines on the left side, starting from point C to A, refer to area C, and the calculation starts from point A to C.

The formula Reading for the X point is:

A	50
B	30
C	20
Total:	100 %

The formula Reading for the Y point

A	60
B	0
C	40
Total:	100%

Fig. 3: Hydrilla verticillatta Ash Glaze Formula Firing Temperature 1250 °C

Fomula Point (based on 100%)	Feldspar or China Clay %	Hydrilla Verticillata Ash %	Choose one Chemical (Calcium Carbonate, Ball Clay, Neph Syenite, Silica, Soda Ash) %
1	60	40	-
2	50	40	10
3	50	50	-
4	40	40	20
5	40	50	10
6	40	60	-
7	30	40	30
8	30	50	20
9	30	60	10
10	30	70	-
11	20	40	40
12	20	50	30
13	20	60	20
14	20	70	10
15	20	80	-
16	10	40	50
17	10	50	40
18	10	60	30
19	10	70	20
20	10	80	10
21	10	90	-
22	-	40	60
23	-	50	50
24	-	60	40
25	-	70	30
26	-	80	20
27	-	90	10
28	-	100	-

Fig. 4: Hydrilla Ash Glaze Formula With Oxides

Firing Temperature 1250 celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
Feldspar	-	-	-	-	-
Hydrilla Ash	90	90	90	90	90
Silica	10	10	10	10	10

Firing Temperature 1250 celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
Feldspar	-	-	-	-	-
Hydrilla Ash	90	90	90	90	90
Calcium Carbonate	10	10	10	10	10

Firing temperature 1250 celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
Feldspar	10	10	10	10	10
Hydrilla Ash	90	90	90	90	90
China Clay	-	-	-	-	-

Firing Temperature 1250 Celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
China Clay	30	30	30	30	30
Hydrilla Ash	60	60	60	60	60
Calcium Carbonate	10	10	10	10	10

Firing Temperature 1250 celcius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
China Clay	10	10	10	10	10
Hydrilla Ash	70	70	70	70	70
Ball Clay	20	20	20	20	20

Firing Temperature 1250 celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
Feldspar	20	20	20	20	20
Hydrilla Ash	50	50	50	50	50
Nep. Syenite	30	30	30	30	30

Firing Temperature 1250 celsius					
Glaze Chemical	**Cobalt 4 gm**	**Red Iron 10 gm**	**Yellow Iron 4 gm**	**Copper 2 gm**	**Manganese 10 gm**
Feldspar	10	10	10	10	10
Hydrilla Ash	70	70	70	70	70
G. Borate	20	20	20	20	20

Firing Temperature 1250 celsius					
Glaze Chemical	Cobalt 4 gm	Red Iron 10 gm	Yellow Iron 4 gm	Copper 2 gm	Manganese 10 gm
Feldspar	-	-	-	-	-
Hydrilla Ash	90	90	90	90	90
Paddy Ash	10	10	10	10	10

Firing Temperature 1250 celsius					
Glaze Chemical	Cobalt 4 gm	Red Iron 10 gm	Yellow Iron 4 gm	Copper 2 gm	Manganese 10 gm
Feldspar	20	20	20	20	20
Hydrilla Ash	60	60	60	60	60
Soda Ash	20	20	20	20	20

Hydrilla Ash Glaze Formula Using Oxide

The use of oxide in the hydrilla ash glaze on white clay produces a captivating effect. The glaze surface becomes glossy and shiny with bright colors. The researcher has reduced the content of copper and cobalt from 4% to 1% as a result of the experiment carried out previously. Copper does not produce a bright green color but a dark brownish green color instead. Cobalt also leaves a dark blue color due to a high percentage of ferum in the hydrilla ash. The mixture of red ferum, yellow iron and manganate produces a dark reddish brown color. Black speckles and spots which appear are the trademarks of plant ash glaze. The 5% of zinc oxide makes the glaze opaque, the speckles clearer and the glaze color brighter. The researcher has chosen the glaze from the second experiment, that is point 14, to be applied on the ceramics products.

The Advantages and Disadvantages of the Hydrilla Ash Glaze

There are a number of advantages to the use of the hydrilla ash glaze on ceramics. Due to their chemical characteristics, the hydrilla weeds can be used as a good glaze composition. The weeds can be found in abundance in fresh water locations and can be obtained without any cost incurred. Additionally, the process of making the hydrilla ash glaze is undemanding and inexpensive. The equipment used can be obtained at a very low cost from hardware stores.

Additionally, the process of producing hydrilla ash glaze is economical in the sense that only three to four ingredients are required, compared to other types of glaze, which require at least seven to eight ingredients for its production. Moreover, the consumption of electricity required is reduced as the melting point for the hydrilla ash glaze is low, which is between 1200 ^{0}C and 1250 ^{0}C. By comparison, other plant ash glazes have higher melting points centred around 1280 ^{0}C.

The aesthetic value found in the glaze is at par and even goes beyond the magnificence of other glaze such as mat, transparency, tenmoku and others. Hydrilla ash glaze has its own original dark greenish orange color with attractive fine speckles which enhances the pottery with interesting textures.

Certain disadvantages to the use of hydrilla ash glaze on ceramics also exist. As the hydrilla has 90% water content, there may be difficulties in obtaining sufficient amounts of ash glaze after the drying process. To obtain a kilogram of hydrilla ash, at least 50 kg of hydrilla weed are required. The soft tissue of the hydrilla makes the weed extremely light when dried. This is different from other plants which grow on the ground as these have leaves, branches and roots which make them heavy.

Hydrilla must also be completely dried before it can be processed. Otherwise, it may become mouldy, creating an unfavorable smell. Damp hydrilla needs at least three or four days of burning for it to turn into ash. The dried ones, however, require only three hours of burning. Lastly, the ash water can cause skin irritation.

Despite the disadvantages, the use of the hydrilla ash glaze can be of use to students, ceramic artists, pottery makers, and also manufacturers of chemical products.

Conclusion

The existence of hydrilla in most parts of the world is commonly perceived as a threat to the economic and social development of people and communities in the surrounding areas. Various methods and technologies have been employed to abolish its presence but all attempts at doing so almost always turn out to be unsuccessful. Such is the case at the UNIMAS lake. Although clearing is carried out once in every three or four months, the hydrilla weeds keep on growing in the lake.

In my search for the presence of hydrilla in other localities in Kuching, I have discovered that hydrilla weeds are also found at the water reserve in front of the Kuching North City Hall building, the drainage in the BDC housing area and the UNIMAS students' hostel in Sri Muara. In Selangor, the hydrilla weeds are found at the Subang Jaya's Lake, and in Perak at the Banding Lake. In Terengganu, they are spotted at the Kenyir Lake near the Sultan Mahmud National Hydro Station. Such discoveries clearly show that the hydrilla weeds can easily be found in abundance in watery or muddy localities throught the country.

Findings from studies on hydrilla weed as an ash glaze composition can undoubtedly change the public's negative perception towards its use. This study has shown that the hydrilla weeds can make a significant contribution to the local ceramics industry.

The exceptional quality of the hydrilla ash is its ability to produce a flawless glaze using only the ash as an ingredient. The glaze surface has a fine glossy layer with fine-looking colors. The glaze is also economical – the reseacher used only three chemical ingredients including the hydrilla ash in his experiment. The number of ingredients is very small compared to other glaze formulae which require the use of at least six or seven chemicals for their production. Furthemore, the minimal number of chemicals used also lowers the production cost.

The experiment on hydrilla weeds together with various raw materials and ceramics coloring has shown that hydrilla is capable of producing attractive glaze with perfect characteristics. The hydrilla ash glaze has a big potential to be commercialized as an economic resource. Based on the chemical analysis, the hydrilla ash is a flux agent that reduces the temperature of the chemical substance in a glaze formula. With a high flux content, the hydrilla ash produced matures and becomes glassy at a temperature of 1200 °C.

I am of the opinion that the hydrilla weed and many other plants can be used as glaze. This weed can reproduce quickly and in abundance without the need for proper care. Its existence and benefits should therefore be fully exploited. My experiment has proven that ash glaze from the hydrilla is indeed beautiful, perfect and at the same time very economical.

References

Gupta, O.P. 1993. *Weed Management: Principles and Practices*. India: Agro Botanical Publishers.

Monaco, Ashton. 1991. *Weed Science: Principles and Practices*. New York: John Wiley & Sons, Inc.

Lembi, Ross. 1985. *Applied Weed Science*. New York: Macmillan Publishing Company.

Murphy, Pieterse. 1993. *Aquatic Weeds*. Great Britain: Oxford Science Publications.

Leach, Bernard. 1976. *A Potter's Book*. London: Faber and Faber.

Rhodes, D. 1977. *Clay and Glazes for the Potter*. London: Pitman Publishing.

Rogers, Phil. 1991. *Ash Glazes*. London: A& C Black.

Mansfield, Janet. 1986. *Pottery*. Australia: Fontana/ Collins.