Indonesian Essential As Biocidesin Traditional-Based Artefact Consertvationstudy : A mini Review[1]

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Abstract : Many essential oils have biocides activity, such as antifungal, antibacteria, and insecticide. The biocide activity depends on the active compound in the oil and microbial species.Research on the application of essential oils as biocides widely developed in many fields. The traditional living practicesfor material preservation using essential oil containing natural product are found in many regions in Indonesia. In Java, vetiver (known as akarwangi) is put inside cloth cabinet for protecting the fabric from insect and fungi. Clove extract (combine with tobacco) is commonly used as cleaning and protecting solution for traditional wooden houses in northern part of Central Java. There are still many other examples of traditional natural product use for maintaining daily tools.The objective of this article was to explore the potentiality of Indonesia's essential oils as an eminent conservation material.

Essential oils from natural product have great prospect to be developed as an artefact conservation material, although intensive research are needed. The results fromseveral researches conducted in Borobudur Conservation Laboratory showa promising prospect. Clove leaf oil is scientifically proven as antifungiand antitermite in wooden artefact conservation (Cahyandaru, 2010). Piper oil and Sitronella oil areeffective for wooden artefact conservant, while the antifungi and antitermite properties are also scientifically proven (Haldoko, 2014). The essential oil of Cymbopogonnardus L (lemongrass) has a positive activity against fungi on andesite stone (Riyanto et al., 2016). Other researches are still on-going for anti-lichenes using clove oil, nutmeg oil, and curcuma oil.

Keywords: Essential oil, Biocide, Conservation

Abstrak : Banyak minyak atsiri memiliki aktivitas biosida, seperti antijamur, antibakteri, dan insektisida. Aktivitas biosida tersebut tergantung pada senyawa aktif dalam minyak dan spesies mikrobanya. Penelitian tentang penerapan minyak atsiri sebagai biosida banyak dikembangkan di berbagai bidang. Praktik kehidupan tradisional untuk pengawetan bahan menggunakan produk alami yang mengandung minyal atsiri di temukan di banyak wilayah di Indonesia. Di Jawa, larasetu (dikenal sebagai akar wangi) dimasukkan ke dalam lemari kain untuk melindungi kain dari serangga dan jamur. Ekstrak cengkeh (yang dicampur dengan tembakau) biasa digunkan sebagai larutan pembersih dan pelindung untuk rumah kayu tradisional di Jawa Tengah bagian utara. Masih banyak contoh lain dari penggunaan produk tradisional untuk memelihara peralatan sehari-hari. Tujuan dari artikel ini adalah untuk menggali potensi minyak atsiri Indonesia sebagai bahan konservan yang unggul.

Minyak atsiri dari bahan alami memiliki prospek yang baik untuk dikembangkan sebagai bahan pelestarian artefak, walaupun masih dibutuhkan penelitian yang intensif. Hasil dari beberapa penelitian yang dilakukan di Laboratorium Balai Konservasi Borobudur menunjukkan prospek yang menjanjikan. Minyak daun cengkeh secara ilmiah terbukti sebagai antijamur dan antirayap pada konsevasi artefak kayu (Cahyandaru, 2010). Minyak lada dan minyak sereh juga efektif untuk konservasi artefak kayu, dimana sifat antijamur dan antirayapnya telah terbukti secara ilmiah (Haldoko, 2014). Minyak atsiri sereh (*Cymbopogon nardus* L) memiliki aktifitas positif untuk mematikan jamur yang tumbuh pada batu andesit (Riyanto et al., 2016). Penelitian lain masih berlangsung untuk antijamur-kerak (*lichene*) menggunakan minyak cengkeh, minyak pala, dan minyak kunyit.

Kata kunci: Minyak atsiri, biosida, konservasi

I. Introduction

Indonesia has many cultural heritageslocated in various regions. Indonesia's cultural heritages are made from various types of material, such as stone, brick, wood, metal, ceramic, paper, cloth, and others. All cultural heritagesare important to be preserved in order to provide maximum benefits and can be passed on to future generations. Stone is one example of cultural heritage material commonly used in Indonesia, found mainly of cultural classical period of Hindu-Buddhist

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period. This period left many majestic architecturalstone temples.

Stone and other heritage material weathering can occur through a chemical process because the dissolution of mineral elements or through biological processes. Biological processes that occur is the growth of organisms on the surface and pores in combinationwith water, sunlight, and nutrients. Further growth of the organism also can initiate the chemical weathering reactions.

Conservation of the cultural heritage material is important to be done by controlling the factors that caused the weathering. One effort that can be performed is to control the growth of organisms which directly or indirectly causes the weathering. Organisms that grow on heritage material is bacteria, fungi, algae, lichenes, mosses, and higher plants. Higher plant relatively easy to control because it can be taken at the time when it is still in early development. But the growth of other organisms like moss, algae, fungi, and lichenesare extremely rapid and difficult to control. Various control measures need to be carried out both physically/mechanically and chemically. Biological control can be done by using chemical biocide material which is a strong toxic compounds. Along with the awareness of the environment, the useof these materials have been minimized due to a negative impact on the long-term and direct impact to humans.

In some cases,the conservation of cultural heritage is carried outin physical/mechanical method with simple tools such as brushes and water. This method is effective but temporary, because of the very rapid organism growth, so that the cleaning process must be carried out continuously and repeatedly. Alternative materials to control organisms need to be further investigated to obtain more effective and efficient conservation methods. The ideal material should be effective yet safe for cultural heritage in the long term as well as safe for humans. Essential oils are ones of the materials of interest to be studied, since Indonesia is a country with abundant essential oil products.

Indonesia is a large archipelago in a tropical region with mega-biodiversity (second in the world, after Brazil), 60% of about world's 2 million plants is found in Indonesia. Essential oil is one of natural products taken from plant resources. Due to the richness of its biodiversity, more than 150 essential oils are known to be found in Indonesia and about 40 of them are commercially traded. According to data from Indonesia Essential Oil Council (Dewan Atsiri Indonesia), Indonesia produces about 20 types of exported essential oils, in which 12 types are dominating the international market (ie: Patchouli/Nilam, Cananga, Vetiver/Akarwangi, Citronella/Seraiwangi, Nutmeg/ Pala, dan Clove/Cengkeh).

These essential oils are mostly used industrially as fragrance and flavour, while some are used in pharmacy and biocides. Every essential oil contains particular compounds which have specific properties and activities. Essential oils from aromatic plants contain active compounds which can be used as a pesticide. This relates to the character that is able to kill, repel and inhibit the growth of organisms. Some essential oils are known to have pesticide properties, such ascloves leaf oil (Eugenia aromatic), nutmeg oil (MryristicafragansHoutt), citronella oil (Andropogonnardus), and cinnamon oil (Cinnamomum spp.). Some essential oils contain benzene and hydroxyl groups derivatives, so they havepesticide activity. The active component in the essential oil has properties that could control the growth of some types of organisms, including bacteria, fungi, and algae.

Essential oils are prospective to be developed as a biocide as they are inabundant with easier availability as well as relatively inexpensive. Essential oils could also be applied safely because it has a low toxicity level for humans and even some types are declared safe for humans. Essential oil-based pesticide registration has passedthe EPA (Environmental Protection Agency) regulation and declared as GRAS (Generally Recognized as Safe) so they aresafe for humans and the environment. Essential oil-based pesticides also have a low MIC (Minimum Inhibitory Concentration) and LD (Lethal Dose 20) value, good compatibilitywithagricultural crops, and residue-free characterif applied on agricultural crops. Essential oils have a great potentiality to be studied in relation to the effectiveness forcontrolling organisms that are a factor in the weathering of andesite-based cultural heritage. The use of essential oils is expected to replace the current conservation method because it is less effective. Essential oils can be applied including the cultural heritage with the very high number of visitors like Borobudur. Conservation with a strong poison

Figure 1. Table on Essential Oils Producing Plants

NO.	PLANT	PART OF PLANT	ESSENTIAL OIL	MAJOR COMPONENT
1	Clove	Flower/ leaf	Clove	Eugenol
2	Lawang	Bark	Lawang	Eugenol dan safrol
3	Pine	Bark/wood/sap	Terpeuntin	Alfa-pinen
4	Sandalwood/ Cendana	Root/trunk bark	Cendana	Santanol
5	Eucalyptus	Leaf	Cajuput	Sineol
6	Cananga	Flower	Cananga/ylang	Ester
7	Cinnamon	Bark/trunk	Cinnamon	Sinamilaldehida
8	Lemongrass	Leaf	Citronella	Sitronelal, sitronelol
9	Patchouli/ nilam	Laef	Patchouli	Patchouli alkohol
10	Mint	Leaf	Pippermint	Mentol
11	Vetiver/ akarwangi	Root	Vetiver	Vetiverol
12	Fennel/ Adas	Seed	Fennel	Anetol, estragol, fenson
13	Gondopuro	Leaf	Gondopuro	Metilsalisilat

pesticide ingredients are not allowed to do because it can producenegative effects to the visitors.

II. Discussion

A. Essential Oil

Essential oils are oils obtained by distillation, extraction and enfleurationof plant parts: roots, stems, bark, leaves, flowers, fruit. The examples of essential oil producing plants can be seen in the table below. Essential oils which can be easily groupedbase on its components are a base material to be converted into other products such as citronella oil, clove oil, peppermint oil and turpentine oil. Essential oils, which are difficult to separate into its components, are used directly such as patchouli oil, ylang-ylang oil, vetiver oil.

Essential oils can be isolated from many parts of the plant such as leaves, stems, roots, berries, bark and flowers. Various types of isolation techniques for producing essential oils aresteam distillation, boiled distillation, extraction, enfleuoration. Steam distillation is suitable for the isolation of essential oils from lemongrass, ylang-ylang and clove. Boiled distillationare very suitable for the isolation of medicinal essential oils such as ginger, curcuma, turmeric, Curcumamangga, and others. For technique by boiled distillation, raw materials should be grinded until fine enougth and blended with water by using an appropriate composition. This technique requires a small flame so that the sample does not burned. A technique widely used for the isolation of essential oils made from hard case of the leaves, stems and roots is a water vapour distillation. The process is determined by the steam pressure produced by the boiler. For optimised results, theraw materials are usually needed to be dried to reduce the water content and chipped to remove all the essential oils in the plant tissue. Analysis of the active compound components in the essential oil can be done by gas chromatography mass spectrometry (GC-MS).

B. Essential Oil Activity

1. Utilization of Essential Oils as Biocide Materials
   Some types of essential oils are evidenced to show a biological activity against microbes or insect pests and vectors of pathogens that harm humans, animals, and plants. The potential use of essential oils as pesticides is also very

high in terms of biological activity, efficacy, compatibility, target organism, as well as safety for the environment and human health.

Biological activity of essential oils against microbes has been studied mainly against pathogenic bacteria in humans and animals.The resultssuggest that a number of essential oils has an activity against pathogenic bacteria both gram-negative and positive with a varied value of MIC (Minimum Inhibitory Concentration). Some essential oils are also reported to have an activity against pathogens in plants (Hartati et al., 1994; Supriadi et al., 2008; Vasinauskiene et al., 2006; Kotan et al., 2007).

According to EndangSusilawatiShelef (1987), the antimicrobial component contained in essential oilsare mainlyphenolic compounds with molecular weight between 150 and 160, which are having OH group. Eugenol, carvacrol and thymol are the major antimicrobial components that are existed on cloves, pepper, and cinnamon. Generally, gram-positive bacteria were inhibited at lower concentrations compared with gram-negative bacteria. Examples of bacteria whose growth is stunted by essential oil are: E. coli, B. cereus, B. subtilis, A. flavus and A. parasiticus. The mechanism of inhibition by phenolic compounds as antibacterial is by poisoning the protoplasm cells and destroying cells to inhibit a precipitation ofmicrobial cell protein. Substances presented in the essential oil can cause denaturation of proteins that are damaging to bacteria cell membranes. Antimicrobialproperties of each different type of essential oils are various, and the effect to any microbes are also various.

2. Essential Oils Activity as Antibacterial and Antifungal

Many studies indicate that a number of essential oils has activity against pathogenic bacteria. Essential oils also has high activity against bacteria in plants (Hartati, 2012).Results of several studies indicate that a number of essential oils also have activity against fungi. Antifungal activity by the essential oil also relates to bioactive compounds, especially phenol monoterpenikthymol, karvakrol and eugenol (Isman, 2000).

Many essential oil anti-fungus activitiesare already tested. Some oils, such as oils derived from cinnamon, nutmeg and cloves, and other essential oils reportedly are effective to inhibit the growth of fungi Aspergillusflavus and the production of aflatoxin (Mahmoud, 1999). Clove oil is effective in suppressing the growth of the fungus Colletotrichummusae,Lasiodiplodiatheobromae, and Fusariumproliferatum (Ranasinghe et al., 2002). Essential oil of basil (Ocimumbasilicum L.) can inhibit the growth of a wide-rangedfungi (22 species) including Aspergillusflavus and A. parasictus. Nutmeg essential oil can inhibit the growth of fungus F. solani, A. terreus, A. fumigatus, Penicillium sp., F. moniliforme, A. flavus, A.oryzae, and A. niger (Nilima et al., 2012).

Yang and Clausen (2010) specifically performed a research on inhibition of a fungus that commonly grows on wood as building material. Mold growing in homes potentially has a very adverse health effects. Inhibition of growth is done by using essential oils. The research is focused on the inhibition of the growth of fungi and molds in the laboratory and its application as a material for fumigation.

According Hartati (2012) a number of essential oils has activity against pathogenic bacteria both gram-negative and positive with varied value of MIC (Minimum Inhibitory Concentration). A number of essential oils also have activity against fungi. Antifungal activity possessed by the volatile oil associated with phenolic compounds, especially thymol, and eugenolkarvakrol.

C. Essential Oils Applications in Conservation of Cultural Heritage

Many factors causing damages to the historic buildings categorised into chemical, physics and microbiology play an important role in this process. Microbial colonisation of historic material depends

on environmental factors, such as water availability, pH, climatic exposure, nutrient sources, and petrologic parameters, such as mineral composition, type of cement as well as the porosity and permeability of the material. Biotic damage is caused by growth and activity of high-level organisms in the form of plants, animals and microorganism. Organism activity due to growth and metabolism can be accelerated physical and chemical deterioration. Damages could beworsening because of the rock temple is an outdoor building so that it can be damaged due to physical (mechanical), chemical and biologicalfactors that can stand alone or in combination from more than one factor.

The process of growth and metabolism by organisms require water, high relative humidity, nutrients, and photosynthetic light. For example, the damage to stone cultural heritage objectscaused by lichens requires cleaning efforts. Cleaning process using pesticides, fungicides and insecticides synthetic such as AC 322 for cleaning lichens is not recommended, because these materials contain hazardous and toxic materials, especially the content of Arcopal at AC 322 which could endanger humans who undertake conservation efforts, visitors, and environment around cultural heritage objects. These materials can cause cancer because it is carcinogenic and mutagenic.

Alternative metod for the conservation of cultural heritage object by using natural pesticides or vegetable has the potentiality to be developed. Botanical pesticides are pesticides that can be used as an alternative to reduce the use of synthetic pesticides. One of the natural materials that are easily obtainable, low cost and highlyeffectivenare essential oils. Some essential oils contain benzene and the hydroxyl group compounds, so that they can act as botanical pesticides. Essential oil-based pesticideshas passed the registration in EPA (Environmental Protection Agency) and declared safe asGRAS (Generally Recognized as Safe) so they are friendly to humans and environment(Riyanto, 2016).

Borego, er al (2012) conducted a study to test the activity of several essential oils biocides against microorganisms that destroy culturally important manuscripts. Various essential oils were tested with the agar diffusion method on several types of fungus and bacteria. Fennel and garlic oil showed betterantifungal activity, while the oregano oil is not only effective in killing the fungus but also preventing the formation of spores. Clove oil, garlic, and oregano showhigh anti-bacterial activity.

Fierascu, et al (2012) conducted a study on the use of natural materials as a deterrent against artefacts'biological weathering. Materials tested are not only essential oils but also various natural products. Anti-fungal testing was done using extracts from natural materials. Verma, et al (2011) conducted a study to test the anti-fungal properties of some essential oils. Anti-fungal test done using isolates fungus that grows on the building. Essential oils tested were essentialoilsfrom Eucalyptus globulus L (Myrataceae) plant, Menthapiperita Linn. (Lamiaceae), Oleaeuropaea Linn. (Oleaceae), Cedrusdeodara (Roxb) Seeds of Piper nigrum Linn. (Piperaceae), seeds of Ricinuscommunis Linn. (Euphorbiaceae), Syzygiumaromaticum (Linn.) and peel ofCitrus limon (Linn.)

Essential oils are also investigated by Bhatnagar and Jain (2014) for historic buildings. The study uses essential oils from peppermint, cinnamon and pine resin as the material conservation to inhibit mold growth in India Gwalior Fort. This type of fungus is suspected of having inhibition of Penicilliumsp and Fusarium sp, while it grows widely in the fortress.

Lemongrass essential oil was studied as a biocide against fungi on andesite stone surface. The essential oil of Cymbopogonnardus L analyzed in the study was dominated by a high percentage of citronelle (47.30%), beta-citronellal (16.05%), trans-geranial (12.98%), citronellyl acetate (4.91%), trans-caryophyllene (4.70%) and delta-cadinene (2.15%). This research shows the concentration of the essential oil of Cymbopogonnardusis increased in relation to increasing of activity against fungi on the stone surface (Riyanto, 2016).

Conclusion

The traditional living practices for material preservation using essential oil containing natural products are recorded in many regions in Indonesia. In Java, vetiver (known as akarwangi) put in cloth cabinet for protecting the fabric from insect and fungi. Clove extract (combine with tobacco) commonly used

as cleaning and protecting solution for traditional wooden houses in northern part of Central Java. There are still many other examples of traditional natural product use for maintaining daily tools. Essential oils from natural product very potential to be developed as artefact conservation material, although intensive research are needed. The result of some research conducted in Borobudur Conservation Laboratory is showing promising result. Clove leaf oil is scientifically proven as antifungi and antitermite in wooden artefact conservation (Cahyandaru, 2010). Piper oil and Sitronella oil are effective as wooden artefact conservant, while the antifungi and antitermite properties are also scientifically proven (Haldoko, 2014), eventhough antifungi property of piper oil is less effective than sitronella oil. The essential oil of Cymbopogonnardus L (lemongrass) has a positive activity against fungi on andesite stone (Riyanto et al., 2016). Other researches are still on-going for anti-lichenes using clove oil, nutmeg oil, and curcuma oil.

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