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# Introduction of Aquatic Plant Diversity as An Educational Model for Phytoremediation in the Purwodadi Botanic Garden

Rony Irawanto<sup>1,2\*,</sup> Reka Permata Sari<sup>3,</sup> Bagyo Yanuwiadi<sup>1,4,</sup> Amin Setyo Leksono<sup>1,4,</sup> and Soemarno<sup>1,5</sup>

<sup>1</sup> Universitas of Brawijaya, Enviromental Studies Program, Malang, Indonesia, 65145

<sup>2</sup> Research Center for Environmental and Clean Technology - BRIN, Serpong, Indonesia, 15314

<sup>3</sup> Universitas of Muhammadiyah, Science Education Study Program, Sidoarjo, Indonesia, 61215

<sup>4</sup>Universitas of Brawijaya, Faculty of Mathematics and Natural Science, Malang, Indonesia, 65145

<sup>5</sup> Universitas of Brawijaya, Faculty of Agriculture, Malang, Indonesia, 65145

**Abstract** - Purwodadi Botanic Garden is an ex-situ plant conservation area which has five main functions, namely: conservation, research, education, ecotourism and environmental services. This article aims to measure understanding of the phytoremediation model for aquatic plants in the Purwodadi Botanic Garden. This research uses mixed methods with qualitative and quantitative approaches. Data was obtained from direct observation of aquatic plants in the garden and questionnaires from technical assistance, environmental education lectures and socialization activities. This research presents the process of introducing aquatic plants diversity over the last eight years, from manual models such as booklets, leaflets and modules, to electronic models using QR codes, websites, videos with information labels, banners and brochures. Apart from that, it also presents public perceptions regarding environmental phytoremediation technology using aquatic plants. Because 48% to 67% of respondents lack sufficient knowledge. They still do not know the potential of plants or about phytoremediation. Thus, the educational model for solving environmental problems (water pollution) using aquatic plants becomes very important.

Keywords: Phytotechnology, Plants Diversity, Environmental Education, Botanic Garden.

## 1. Introduction

Botanical Gardens in Indonesia are plant conservation institutions that are undoubtedly the pillars of saving plants diversity from extinction. The Scientific Conservation Area (SCA) of Purwodadi Botanic Garden is one of the botanical gardens located in Purwodadi District, Pasuruan Regency, East Java Province. Purwodadi Botanic Garden or abbreviated as PBG is a conservation area ex-situ which protects various specifications of dry lowland plants. PBG is known as the Hortus Dry Climate Purwodadi. PBG has the task of conserving tropical plants in Indonesian. One of the tropical plants that has the potential to improve the aquatic environment is aquatic plants.

The collection of aquatic plants is spread across several ponds in PBG. Aquatic plants are generally known as ornamental plants, because of the beauty of their shape and color, both in leaves and flowers [1]. Aquatic plants are generally grouped into three, namely: a. Emerging are plants that

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appear above the surface of the water, but their roots are in the sediment; b. Submerged are plants that are entirely in water; c. Floating is a plant whose entire part or only part, for example the leaves, floats on the surface of the water [1].

Plants that have been planted and become collections will be managed, recorded, and utilized in line with consistent efforts made by PBG in protecting plants through five roles: conservation, research, education, ecotourism, and environmental services. Efforts to explore the potential of aquatic plants, especially in phytoremediation research and its widespread application. Therefore, this research needs to be conducted in introducing a phytoremediation education model using the diversity of aquatic plants in PBG. Departing from previous innovative ideas utilizing natural technology, over time it can be realized through the latest research that is simple and follows the development of the times.

## 2. Material and Methods

This research design uses a mixed method with a quantitative and qualitative approach. Departing from initial ideas during a guest visit to PBG regarding the application of phytoremediation techniques from UTM Malaysia, ITS Surabaya (2015) and Puskimbang PUPR Bandung (2016).

The research was conducted for five years from 2019 to 2024. Quantitative data were collected through direct observations in the field, questionnaire data involving environmental education lecture participants specifically held by the campus (ITS, UNAIR: 2018; UNITRI: 2019; ITK, UNPAD, UINSA: 2021) or generally carried out by the community (PWEC, KS: 2018; MTI: 2020) or agencies (CPALIM, DPRKCPK: 2024). No less than 295 respondents, both lecture participants (150) and the general public (145).

Measurements were made using percentages to obtain numerical data that were analyzed statistically. Qualitative data were obtained through in-depth discussions with participants to explore views and experiences as well as socialization activities or dissemination of science and technology that were carried out consistently. Data were analyzed using descriptive methods.

The materials used include previous research results, relevant theories, and recent research. While the equipment used includes cameras, stationery, question forms, power points, activity pamphlets, photos or videos of meetings. The results and discussions are carried out by processing and rearranging the data and information obtained and then presented in a description.

#### 3. Result and Discussion

#### 3.1 Purwodadi Botanic Garden (PBG)

Purwodadi Botanic Gardens, in terms of its existence, has comparative advantages that other institutions, both government and non-government, do not have. The plant collection supported by related data and systematically recorded in a digital database, the large number of collections originating from various regions in Indonesia, and scientific information regarding the potential and development of science, make PBG stronger compared to other similar institutions [2].

Based on data over the past five years, the average number of visits in general was 102,169 people, compared to visitors who used botanical garden services, which amounted to 11,647 people. So that only about 6% of visitors really understand the main function of PBG [2]. This shows the fact that the general public's understanding of the main tasks and functions of the botanical garden is very lacking, which causes PBG only known as a place for recreation/tourism. Meanwhile, other

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important functions such as conservation, research and education are only known to a small number of visitors/service users [2].

KRP has the task of conserving Indonesian tropical plants. One of the tropical plants that has the potential to improve the aquatic environment is aquatic plants. Management of plant collections is not merely conservation but also as a medium for environmental education. Therefore, a natural and beautiful collection arrangement is needed and has an educational function [3].

Research [2] showed that there were 45 respondents who were given a questionnaire consisting of 36.8% men and 63.2% women, as many as 94.7% knew the main function of the botanical garden as a place of conservation. PBG is a place for plant conservation that has a collection of plant species both from within the country and abroad. The plant collections in PBG include plant species from various regions in Indonesia, rare plants and plant collections from abroad. Based on the results of the perception questionnaire analysis, it turned out that 81.6% stated that the existence of PBG can make visitors aware of the importance of public awareness and concern for biodiversity, especially plants and their vital role in human life. Respondents are aware of the threats faced and the importance of efforts to conserve plant diversity including aquatic plants.

#### 3.2 Aquatic Plants in PBG

The diversity of aquatic plants has value from the morphological and ecological aspects for environmental management. Likewise, natural technology in the form of phytoremediation techniques as a solution to improve the environment that is environmentally friendly needs to be introduced massively. The introduction of both begins with an in-depth understanding of the concept of aquatic plants, species of aquatic plants, characteristics of aquatic plants, and the ability to survive in clean and polluted water environments. After a basic understanding is formed, phytoremediation techniques can be introduced by promoting aquatic plants as the main tool to achieve the goal of improving the polluted environment. When both can be recognized, understood, and needed, then the important role of PBG in conservation (preservation) of plants, research, education can be realized. Even now the function carried out by botanical gardens is not only limited to conservation, research and education, but also the benefits of environmental services such as providing pure oxygen, environmental recovery / absorbing pollutants, collecting / catchment of rainwater, green open spaces / city parks need to be introduced more to stakeholders / policy makers and the public in general.

The species of aquatic plants that have been inventoried, characterized and selected are: Acanthus ilicifolius, Actinoscirpus grossus, Ceratophyllum demersum, Coix lacryma-jobi, Echinodorus radicans, Lemna minor, Ludwigia octovalvis, Pistia stratiotes, Sagittaria lancifolia, and Salvinia molesta. As briefly described below.

- 1. *Acanthus ilicifolius* is a family Acanthaceae inhabiting the estuary rivers, lake shores, mangrove forests, growing up to 500 m above sea level. Its local name is "jeruju ungu", has opposite leaves, short oval-shaped stems with pointed tips like an arrow, the edges are shallowly lobed with thick, stiff, and sharp thorns; the leaf surface is shiny light green and wavy. Has compound flowers in the form of grains, flowers are purple, blue, or white [3].
- 2. *Actinoscripus grosus* is a family Cyperaceae easily found in humid, wet areas, and have a temperate and subarctic climate. This plant can also live in tropical areas such as Indonesia. Its local name is "mensiang". When it is two weeks old, it grows to a height of about 30 cm, has rhizome roots, a triangular stem, and reproduces through generative reproduction [4].

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- 3. *Ceratophyllum demersum* is a family Ceratophyllaceae lives in water. Its local name is "ganggang air", grows horizontally, generally in the form of fibers, is green in color, has many branches and is round, each branch is 1-3 cm long, small leaves form an arrangement, branches repeatedly, has a stiff texture like deer antlers [4].
- 4. *Coix lacryma-jobi is* a family Poaceae which lives in wetlands such as on riverbanks because it usually grows naturally there. Its local name is "jali batu", grows in clumps, grows tall from 1.5 meters to 3 meters with large and dense stems, large and wide leaves like rice; the female flowers of this plant are surrounded by a protective leaf which in the wild form is very sharp, shiny, thick, and hard so that it is not easily torn [4].
- 5. *Echinodorus radicans* is a family Alismataceae which lives in waters or humid areas, half submerged. Its local name is "melati air", it has single, stiff leaves with squared stems that are rounded towards the base of the leaf. The edges of the leaves are flat, the leaf veins are joined from the base to the tip of the leaf. The inflorescence emerges in the middle of the leaf stalk, arranged like a string of umbrellas, with a thin white crown that is larger than the petals, white and yellow stamens [1].
- 6. *Lemna minor* is a fast-growing aquatic plant from the family Lemnaceae which lives in tropical to subtropical waters. Its local name is "mata lele", has small oval leaves measuring 0.5 cm, its roots hang down about 1 cm long [3].
- 7. *Ludwigia octovalvis* is an aquatic herbaceous plant from the family Onagraceae. Its local name is "lakun air", has many branches up to 2-4 meters high, narrow lanceolate leaves and green, smooth and shiny leaf surface, 1 cm long leaf stalk, has single flowers with 4 petals and yellow, the fruit is in the form of a capsule 1.7-4.5 cm × 0.2- 0.8 cm, cylindrical, thin-walled, and pale brown [1].
- 8. *Pistia stratiotes* is a family Araceae which live in water, are often found in freshwater ponds, rice fields, lakes with calm water conditions, are classified as floating aquatic plant. Its local name is "apu-apu", it has long and thick roots and fine branches [3].
- 9. *Sagittaria lancifolia* is a family Alismataceae which lives in waters or humid areas, half submerged. Its local name is spear leaf, it grows upright and stiff, the leaves are shaped like spears, oval slightly narrowed like elongated ribbons, the leaves are bright green and slightly shiny, the leaf veins are slightly prominent, the flowers are arranged in whorls, each whorl consists of an average of 3 white and rounded crown flowers, the petals consist of 3 small greenish strands [1].
- 10. *Salvinia molesta* is a family Salviniaceae which lives floating on the surface of calm water such as lakes, mines, ponds, swamps, ditches, small canals and rice fields. The local name is "kiambang", has a number of leaves from 12-20 on the stem, irregular branches and segments below the water surface, light green leaves, hanging roots and in the form of fibers with a length of 2-7 cm. This species of plant at first glance looks like a root but is actually a shape-changing leaf that functions like a root [4].

Based on the results of observations in 2016, the results of the content test were above 90% and the results of the plant beauty assessment were above 80% and were reinforced by literature on high adaptability in the field, which has the potential to be used for phytoremediation, namely *Echinodorus radicans*, *Sagittaria lancifolia*, and *Thalia geniculate* [5]. The results of observations at the lowest water level show the species of aquatic plants *Sagittaria lancifolia* perform higher evaporation compared to *Thalia geniculate* and *Echinodorus radicans* which absorbs the least water. While in the

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planting medium Sagittaria lancifolia and Thalia geniculate the growth of white fibrous roots to the surface of the media indicates that the growth and metabolism process is running directly or indirectly affecting the absorption of water. The denser and wider the roots, the greater the need for water to be absorbed [5].

Water is one of the important needs for living things, but if the water consumed is polluted, it can cause problems and health problems. Thus, a solution is needed to resolve this problem. To overcome this, one environmentally friendly effort is to utilize aquatic plants using phytoremediation techniques [6].

#### 3.3 Perception of Phytoremediation

Phytoremediation is a system that utilizes plants to absorb, take, and change pollutants to reduce their levels so that they are not too dangerous. The concept of phytoremediation is quite simple, economical, effective, and takes ecological aspects and has aesthetic value [6]. According to the research results [6], several participants provided perceptions regarding the application of phytoremediation through aquatic plants in thematic PBG, namely:

- 1. Phytoremediation applications can be carried out as heavy metal cleaning. especially in the agricultural sector for water purification, then modern agriculture has a sustainable concept that requires alternatives to increase soil fertility, perhaps it can be overcome because of the decline in organic matter. Expanded studies on the absorption of pollutants and heavy metals while exploring the potential of herbs/shrubs in agricultural land.
- 2. Grouping species of aquatic plants according to their remediation capabilities with attractive flowers can be used as environmental education. Grouping that can be made into a neat garden arrangement and efforts to show changes in water quality before and after aquatic plants are given to ponds/gardens in PBG. Recovery with plants as pollution accumulators. Respondents also said that they had seen the application of phytoremediation directly, namely in England, in villages that had implemented phytoremediation to overcome polluted water, because residents have high and large concerns, made pilot project, such as floating island.
- 3. Dissemination of the potential of aquatic plants in a simple way, apart from being used as an aquatic garden, can be displayed in an aquascape such as an aquarium because of the species of floating aquatic plants easily accepted by kindergarten / elementary school children to recognize species, functions in aquatic habitats. The use of aquatic plants can be developed through aquatic plants thematic modules that do not yet exist. Another suggestion is to provide practical information for junior / senior high school through a guide with communicative language containing stories of the functions of aquatic plants to preserve better water quality.
- 4. Exploring of the aquatic plants potency with the phytoremediation method, it is necessary to remember that the aquatic plants species easy bloom, needed to take care, everything needs to be maintained according to environmental education standards.
- 5. Information development is provided up to date. Ecological projects towards botany/environment can restore river basin areas using aquatic plants, and soil can be linked to applications in phytoremediation.

Based on research by [7], 92.17% of respondents' perceptions that plants were capable of acting as phytoremediation and 48.19% have sufficient knowledge. Both can be the key to increasing public understanding. For example, people who care about cleanliness have several forms of participants

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working together to clean up trash and collect it from house to house [7]. Thus, providing a view of the implementation of phytoremediation, if carried out together, it could create optimal results.

Research by [8] shows that 101 of 150 respondents or 67% of respondents still do not know the potential of plants in sustainable environmental management. This means that most of the respondents who are currently students or academics still do not know about the concept of phytoremediation. The reason for the respondents' ignorance is mostly due to the lack of information spread regarding the potential of phytoremediation as an environmental management effort, either directly or through social media. However, on the other hand, the results of the study showed that 145 respondents or 97% of respondents were curious about the concept of phytoremediation. The environmental conditions in Indonesia are currently experiencing a lot of disturbance or pollution. On the other hand, plants are one of the living things that have the potential to be agents of environmental management. However, there are still many people who do not know about this potential, including academics who are basically agent of change in the progress of a nation. For this reason, concrete steps are needed in conveying information to the wider community.

#### 3.4 Education Model using Aquatic Plants as Phytoremediation

Currently, botanical gardens are not only places for plant conservation, but also as objects of environmental education. The educational role is usually given when group visitors order a guide service, so that the guide will take the group around the garden by providing information about certain plant collections. This role has become popular because visitors can directly enjoy the beauty of the botanical garden while increasing their insight and knowledge about plants [3]. In addition, individual visitors can learn by looking at/reading information boards, but limited information provides ideas for developing an attractive and technological model, namely a QR code module on the aquatic plant collection at PBG [3].

Education is the main forum for introducing what is happening in the environment. According to Hidayatullah, in [9], education is an effort that is carried out consciously and planned to create an active learning atmosphere and learning process to develop potential. Based on research by [9], the number of articles in the period 2010 to 2021 did not discuss much about aquatic plants or phytoremediation. In fact, phytoremediation research has existed long before. The study opened the insight that phytoremediation research is still minimally known to students. For that, massive action is needed on the other hand to conduct continuous research and also disseminate information to the community, especially students, the successors of the nation, the successors of the environment.

The advancement of information and communication technology has changed the way of thinking and made learning easier. The use of technology in education is one of them in the form of website-based learning media, and the use of technology in teaching and learning activities has changing the system in learning media from a conventional pattern to a more modern pattern [10].

The form of utilization of information and communication technology in the Introduction of Aquatic Plants abbreviated as "PenTA" (Pengenalan Tumbuhan Akuatik) by using contemporary media in the form of a website. Previously, this PenTA media existed, but in the form of printed media which was then changed to follow the development of the times and in order to be more easily accessible to many people / the general public, it changed to digital on the website. The creation of a website is useful as one of the new ways that can be utilized in the introduction of aquatic plants in PBG starting from the species, characteristics, and benefits of aquatic plants. In addition, the website can be used to learn or search for information independently, and can be accessed anywhere.

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The use of posters / brochures as a media to introduce the website to the public canbe used for activities inside or outside PBG. Activities inside PBG, where brochures can be distributed directly to visitors, while for activities outside PBG, posters can be used when there is socialization or dissemination or presentation, so that it can simultaneously introduce the role of aquatic plants and promote the garden. So that the latest "PenTA" media for Introduction of Aquatic Plants is electronic media in the website display. To access the website, a QR code is provided which is installed on the pool label board, roll banner poster, or brochure leaflet.

In the context of increasing students' self-awareness, teachers have a role in providing reading references. The problem that is close to students is the condition of polluted rivers, unexpectedly this is an environmental problem that must be considered. To overcome this problem, the existence of an encyclopedia reference book on the diversity of aquatic plant species can be a breakthrough. A reference book that presents species of plants, habitats and their characteristics. Reference books are also called learning media, playing an important role in strengthening students' understanding of biological concepts with environmental problems. Research by [11] shows that the use of encyclopedias does not have significant differences in characteristics, but is able to introduce alternative solutions to water pollution (phytoremediation) using aquatic plants.

# 4. Conclusions and Suggestions

This study shows that previous studies provide a sustainable plan so that the introduction of aquatic plant diversity as a phytoremediation education model is increasingly recognized, its benefits are increasingly applied for the sustainability of healthy and clean waters from pollutants. By referring to several relevant literatures, the phytoremediation model has been developed from a conventional model to a more modern model to penetrate the world of education so that the five main functions of botanical gardens are realized.

The process of introducing aquatic plants diversity / PenTA module from manual models such as booklets, leaflets and modules, to electronic models using QR codes, websites, videos with information labels, banners and brochures. The results of public perceptions regarding environmental phytoremediation technology using aquatic plants only 48% to 67% of respondents lack sufficient knowledge. They still do not know the potential of aquatic plants or about phytoremediation. Thus, the educational model PenTA for solving environmental problems (water pollution) using aquatic plants becomes very important.

So that future research emphasizes the importance of continuing to develop environmental education models, both theoretical and technical, of applying environmentally friendly alternative solutions.

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