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Development of riparian vegetation biodiversity field guide book as river health biomonitoring instruction for class X SMA/MA students

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ABSTRACT

This study aims to (1) determine the biodiversity of riparian vegetation as a biomonitoring of health in the Kuning River and Tambak Bayan, (2) produce a field guidebook for biodiversity of riparian vegetation as a guide for river health biomonitoring for 10th grade high school students, and (3) determine the quality a field guidebook for riparian vegetation biodiversity as a guide for river health biomonitoring which was developed after being assessed by material experts, media experts, peer reviewers, biology teachers and 10th grade high school students. The type of development research used is Research and Development (R & D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) and is limited to ADDE without implementation. The products that have been developed are assessed by material experts, media experts, peer reviewers, biology teachers and fifteen students from SMAN 1 Cangkringan. This research found 108 plant species consisting of 47 families. The product produced is a field guidebook for biodiversity of riparian vegetation for biomonitoring of river health. Product evaluation results according to material experts 85.88% (Very Good), media experts 83.63% (Very Good), peer reviewers 90.57%, (Very Good), biology teacher 91.42% (Very Good), and students 83.20% (Very Good). Based on this assessment, a field guidebook for biodiversity of riparian vegetation for biomonitoring of river health is worthy for use as teaching material for 10th grade high school students on water pollution.

Introduction

Watershed (DAS) is an ecosystem unit whose main elements consist of natural resources, soil, water, vegetation and human resources as actors who utilize these natural

resources. Watershed areas cannot be separated from various problems such as natural resource degradation, pollutant problems, and land use conflicts around the watershed [1]. Various human activities in meeting the needs of their lives derived from industry, households, and agriculture will produce waste that contributes tothe decline in river quality [2]. Ecologically healthy watershed characteristics include low water pollution sources, high water discharge and high vegetation cover. The diversity of tree vegetation and floor vegetation is one of the important components determining the quality of a healthy watershed [3]. One of the river vegetation that forms a unified ecosystem is vegetation in the riparian zone. The characteristics of the riparian zone are adjacent to water bodies, unclear boundaries, linear in shape and extent and the transition between aquatic and terrestrial ecosystems [4].

Riparian vegetation cover is closely related to water quality and can therefore beused as an important tool to assess changes in water quality, biodiversity and river health [5]. River water quality should be monitored and improved to sustain the value and function of rivers for all living things [6]. Therefore, biomonitoring programs should consider riparian vegetation [7]. The use of riparian vegetation as a bioindicator of water quality is still rare in Indonesia, but in some developed countries it has been used. One of them is the Teacher Information Pack in Australia using Riparian Habitat Assessment (RHA) [8].

The aquatic environment that needs to be studied is the Yellow River and Tambak Bayan River which is one of the Opak sub-watersheds in Yogyakarta [9]. The Yellow River is a river that originates from Umbul Wadon spring located at around 1250 meters above sea level and is passed by lava flow when Mount Merapi erupts [10]. Before entering the city of Yogyakarta, the Yellow River passes through a very large fertile agricultural area so that agricultural chemical waste enters and pollutes river water [9]. Tambak Bayan River is a river that flows in Embung Tambakboyo, which covers Condongcatur Village, Depok District, Sleman Regency. Tambak Bayan River is commonly used by local residents for household needs, animals (bathing, drinking), playing and so on. Tambak Bayan River has experienced a decrease in function in the ecosystem due to many human activities, but the color of the water is still quite clear. The rocky riverbed appears to be approximately 0.5 meters deep [11].

The problem of water pollution is important for students to know so that awareness and concern increase. Increasing awareness and concern about environmental problems, especially water pollution, can be done directly or indirectly, one of which is by incorporating the material into learning at school. SMAN 1 Cangkringan is an example of a school in Yogyakarta with an environmental vision and mission and has been awarded the national level adiwiyata award. The development of a field guide book enriches students' knowledge in the field of knowledge and skills [12].

Method

The research will be conducted in February - April 2018 in the upstream riparian of Umbul Lanang, Yellow River and Bayan Pond River. The upstream station is located in Umbulharjo, Cangkringan, Sleman, Yogyakarta at coordinates 7°35'31.3"LS 110°26'28.9"BT with a river width of ± 5 meters and a riparian zone width of ± 100 meters. The middle station is located in Caturtunggal, Depok, Sleman, Yogyakarta at coordinates 7°45'54.5"N and 110°25'06.3"E with a river width of ± 10 meters and a riparian zone width of ± 100 meters. The distance between the two locations are ± 20 km. The tools used are Global Positioning System

(GPS), soil tester, thermometer, TDS meter, lux meter, tape meter, DSLR camera, old newspapers, labels, talia rafia, field assessment form and determination book.

Preliminary Study

The preliminary study was carried out by determining the location through Google Maps and then reviewing the location by finding the location coordinates using the Global Positioning System (GPS). The preliminary study was also carried out to find out the condition of the location used for research. The research location was determined based on the presence of riparian vegetation on the riverbank, this is because each river area has different conditions. The selected upstream location is in Umbulharjo, Cangkringan, Sleman Regency, Yogyakarta. The middle location chosen was in Caturtunggal, Depok District, Sleman Regency, Yogyakarta.

Riparian vegetation data collection

The method used in this study was a field survey, with hand sorting or direct collection techniques. A total of 2 sampling plots were made on both sides of the river flow with a width of 100 m and a length of 20 m [8]. Species found were then identified with FLORA (Steenis, 2006), Flora of the Java Mountains [13], and Atlas Der Baumarien Van Java.

Environmental Parameter Measurement

Environmental parameters measured include light intensity, air temperature, soil moisture, soil pH and TDS. Light intensity (lux) was measured using a lux meter, air temperature measurement with a thermometer, soil pH measurement using a soil tester and TDS measurement by dipping the TDS meter into the sample water.

Data Analysis

The biodiversity of riparian vegetation was analyzed descriptively based on the results of observations during the survey. Riparian vegetation data analysis was carried out in two stages, the first stage was to identify the types of riparian vegetation found in each research location. The identification of riparian vegetation types used FLORA [14], Flora of the Java Mountains [13], and Atlas Der Baumarien Van Java. The second stage is analyzing data descriptively based on the number of species found. The rubric for river habitat quality assessment adopted the Riparian Habitat Assessment (RHA) [8].

Development of a Riparian Vegetation Biodiversity Field Manual

This development research uses the analysis, design, development, implementation, and evaluation (ADDIE) model. However, this research was only carried out at the ADDE stage, the implementation stage was carried out in a limited implementation. The analysis stage includes analyzing needs, curriculum, materials, student characteristics, local potential and instructional analysis. The design stage includes the preparation of a raw material framework, preparation of writing systematics, design of evaluation tools and instrument validation. The development stage produced an initial product that would be validated by the supervisor for product improvement. Revision I is carried out as necessary then the revised results will be validated and assessed by material experts, media experts, linguists and peer reviewers. Furthermore, revision II was carried out to be tested for limited readability on 1 biology teacher and 15 students of class X SMAN 1 Cangkringan. The evaluation stage is carried out evaluation and improvement based on suggestions and input from the assessment results of media experts, material experts and linguists, peer reviewers, biology teachers and student responses.

Results and Discussion

Biodiversity of Riparian Vegetation in the Yellow River and Bayan Ponds

This study of riparian vegetation biodiversity was conducted in two locations, namely the Yellow River and Tambak Bayan River. The Yellow River and Tambak Bayan River are one of the Opak sub-watersheds in Yogyakarta. Based on the results of the research conducted, 108 species consisting of 47 families were found (Table 1). The three largest families are Asteraceae (31.9%), Fabaceae (23.4%), and Poaceae (12.8%).

Table 1. Percentage of riparian vegetation families in Sungai Kuning and Tambak Bayan

No	Family	Number of Species	Percentage (%)
1	Acanthaceae	2	4,3
2	Adiantaceae	1	2,1
3	Amaranthaceae	1	2,1
4	Angiopteridaceae	1	2,1
5	Annonaceae	1	2,1
6	Apiaceae	1	2,1
7	Araceae	3	6,4
8	Arecaceae	1	2,1
9	Asteraceae	15	31,9
10	Balsaminaceae	1	2,1
11	Cleomaceae	1	2,1
12	Combretaceae	1	2,1
13	Commelinaceae	2	4,3
14	Convolvulaceae	1	2,1
15	Costaceae	1	2,1
16	Cucurbitaceae	2	4,3
17	Cyperaceae	3	6,4
18	Euphorbiaceae	5	10,6
19	Fabaceae	11	23,4
20	Gnetaceae	1	2,1
21	Lamiaceae	1	2,1
22	Lauraceae	1	2,1
23	Leeaceae	1	2,1
24	Lemnaceae	1	2,1
25	Malvaceae	4	8,5
26	Melastomataceae	1	2,1
27	Meliaceae	1	2,1
28	Moraceae	5	10,6
29	Muntingiaceae	1	2,1
30	Musaceae	1	2,1
31	Myrtaceae	2	4,3
32	Orchidaceae	1	2,1
33	Oxalidaceae	2	4,3
34	Phytolaccaceae	1	2,1
35	Piperaceae	2	4,3

No	Family	Number of Species	Percentage (%)
36	Plumbaginaceae	1	2,1
37	Poaceae	6	12,8
38	Polygonaceae	2	4,3
39	Pontederiaceae	1	2,1
40	Rubiaceae	4	8,5
41	Sapindaceae	2	4,3
42	Scrophulariaceae	1	2,1
43	Solanaceae	1	2,1
44	Urticaceace	4	8,5
45	Verbenaceae	2	4,3
46	Vitaceae	2	4,3
47	Zingiberaceae	2	4,3

The high percentage of presence of Asteraceae (herbaceous: 80% and shrubs: 20%), Fabaceae (herbaceous: 45% and trees: 55%) and Poaceae (grass: 100%) is possible because the three families have the ability to adapt to dry and humid environments [15]. Asteraceae reproduce using seeds that are very small (2-3.5 mm) and easily carried by the wind, so they can spread quickly. In addition, Asteraceae is very easy to pollinate because many butterflies like it, making it easier to reproduce and spread pollen [16]. Fabaceae is cosmopolite because it can be found from areas with very cold temperatures to warm temperatures, as well as subtropical and tropical areas. In tropical rainforest ecosystems, namely zone I (0 -1,000 meters above sea level) and zone II (1,000 - 3,300 meters above sea level) in Java and Nusa Tenggara, many species of the Fabaceae family are found [17].

Based on the division of life forms, species diversity shows that the riparian vegetation of the Yellow River and Bayan Pond is mostly herbaceous (Figure 1). Herbaceous plants are more numerous at 59 species, than shrubs (20 species) and trees (20 species). The composition and structure of vegetation almost always occurs in natural ecosystems, considering that body size affects competition for living space, nutrients, water and sunlight [18]. The diversity of trees in the riparian zone of the Bayan Pond River is higher at 13 species than the riparian zone of the Yellow River at 9 species. This is because some plants in the riparian Tambak Bayan River are deliberately planted by people around the river, such as Coconut (Cocos nucifera), Gayam (Inocarpus fagifer), Jackfruit (Artocarpus heterophyllus) and Melinjo (Gnetum gnemon). These species are easy to cultivate and have economic value. In accordance with Drastistiyana's research on the diversity and abundance of riparian vegetation in the upper and middle reaches of the Gajah Wong River Yogyakarta that trees in the middle riparian have a higher diversity than the upstream riparian [19].

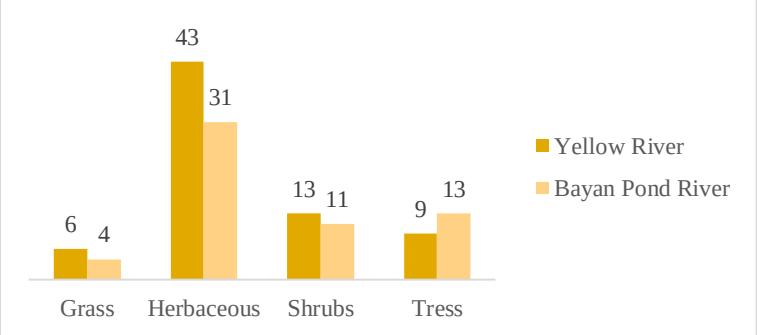

Figure 1. Species diversity of riparian vegetation *life forms*

Life forms studied in this study include grass, herbaceous, shrub and tree vegetation with grass diversity (Sungai Kuning: 6 species; Sungai Tambak Bayan: 4 species), herbaceous (Sungai Kuning: 43 species; Sungai Tambak Bayan: 31 species), shrubs (Sungai Kuning: 13 species; Sungai Tambak Bayan: 11 species) and trees (Sungai Kuning: 9 species; Sungai Tambak Bayan: 13 species). Floor vegetation in the riparian of the Yellow River has a higher diversity than the riparian of the Bayan Pond River. This is because the riparian vegetation of the Yellow River has a wider canopy gap than the Bayan Pond River so that more sunlight enters the ground floor. The results of research by Djufri on the composition and diversity of floor vegetation in Acacia nilotica stands, that the average number of species found in locations with extensive canopy gaps is more, namely 21 species compared to locations with moderate canopy gaps, namely 14 species [20]. This is supported by the statement of Hibbs that locations with wider canopy gaps are found intolerant species, while locations with moderate canopy gaps are found tolerant species [21]. This means that most of the species living in the riparian of the Yellow River are intolerant, that is, species that are able to survive in the open.

Odum categorized aquatic plants into three types: emergent, floating and submerged [22]. Tersembul (emergent plant) is an aquatic plant that the roots are in the water and other organs are on the surface of the water. Floating (floating plant) is an aquatic plant whose roots and stems and leaves float in the water. Submerged (submerged plant) is a water plant that all parts of the body are in the water. Type of life of aquatic plants found in this study are floating plant and emergent plant. The floating plant found in the Yellow River is Lemna minor, while the emergent plant is Elephant Grass (Pennisetum purpureum). According to Brix's research, Lemna minor can reduce pollutants and provide a suitable environment for microorganisms that decompose pollutants [23]. Elephant grass (Pennisetum purpureum) has a very large ability to absorb metal elements from the soil (hyperaccumulator).

Physical - Chemical Conditions in the Riparian Vegetation Environment of the Yellow River and Bayan Ponds

The physical-chemical condition of the riparian environment is one of the supporting factors for the survival of aquatic organisms and can also provide an overview of the condition of these waters [24]. The physical-chemical conditions of the riparian environment of the Yellow River and Bayan Pond can be seen in Table 2.

Table 2. Physical-chemical conditions of the riparian environment of the Yellow River and Bayan Ponds

Physical-Chemical Parameters	Yellow River	Bayan Pond River
Light Intensity (lux)	564	357
Air Temperature (^{0}C)	26	29
Soil Moisture (%)	50	55
Soil pH	7	7
TDS (ppm)	104	114

Light intensity in both research locations ranged from 357 - 564 lux. This means that the light intensity in the riparian Yellow River and Bayan Pond is sufficient for the growth of riparian vegetation. Riparian vegetation getting enough light will affect stomatal openings, sothat transpiration and energy absorption increase [25]. The air temperature atthis research location is between 26 ^{0}C – 29 ^{0}C with soil moisture ranging from 50 - 55%, so it can be said that the temperature in the environment of the Yellow River and Tambak Bayanis normal in a tropical rainforest environment. The ambient temperature in Tambak Bayan River is higher than the Yellow River due to high human activity [26]. The degree of acidity

(pH) of the soil in Sungai Kuning and Tambak Bayan is 7 so it can be said that the pH of the soil is classified as good. The degree of acidity (pH) of the soil in the range of 5 - 8 affects the growth of roots and outside the range of plants can not live [27]. Total Dissolved Solid (TDS) or the amount of dissolved solids in the Yellow River and bayan pond is in the range of 104 - 114 ppm is classified as very good. In accordance with the statement of Heston that TDS < 500 is classified as a very good category.

Table 3. River Habitat Assessment Sheet

	1A 4 points	1B 3 Points	IC 2 Points	1D 1 Points
Border Vegetation	Native vegetation is undisturbed on both sides of the river. Boundary width is more than 30 m.	Threshold vegetation cover is good. Some alien plants present, or loss of native plants.	Little native plant cover.	No cover or grass cover such as a meadow.
	2A 4 points	2B 3 Points	2C 2 Points	2D 1 Point
Bank Vegetation	Native plants in pristine condition. There are no signs of alteration to the site.	Shrubs, trees and reeds with some alien plants Slight signs of site alteration.	Cover is bare ground. Few native shrubs, trees or reeds.	Grass cover with a lot of empty land.
	3A 4 points	3B 3 Points	3C 2 Points	3D 1 Point
Body Vegetation River	Abundant cover with extensive native aquatic plants and snags, logs or rocks, and many overhanging branches.	Cover of snags, logs or rocks with moderate native aquatic plants and overhanging branches.	Little cover. Stream is mostly uncovered, with some woody debris and a few native aquatic plants or overhanging branches.	No cover. No woody debris, rocks, native aquatic plants or overhanging branches. Includes sites with concrete lined channels
	4A 4 points	4B 3 Points	4C 2 Points	4D 1 Points
Bank slope erosion	No erosion. Siltation is present. No riparian areas that has been lost. Usually border is sloping, with low banks covered with grass roots, reeds or shrubs.	Erosion points occur. Riparian is slightly missing, plant cover is good, usually sloping. sloping border, no damage significant damage to fringe structures.	Areas of greater erosion, especially during high flows. Large riparian area Large areas of riparian zone, little plant cover.	Almost continuous erosion. More than 50% of the riparian area is eroding. Little vegetation cover
	5A 4 points	5B 3 Points	5C 2 Points	5D 1 Point
Pools & riffles		Good variety of habitats. Variation in riffle and pool depth.	Little habitat variation. All riffles or pools	Uniform habitat. Straight flow, all riffles or

	Wide variety of habitats. Riffles and pools with varying depths and indentations.	with little depth variation.	pools with uniform depth uniform depth. Like an irrigation canal

Table 4. River Habitat Assessment Ranking Score

Score	Class Assesment	Habitat Condition
18-20	Very good	The location is in a natural or near-natural state.
13-17	Good	Some changes from the natural state.
8-12	Simply	A significant change from the natural state but the habitat is
5-7	Not good	Significant change from the natural state, with reduced habitat; generally subject to erosionand sedimentation issues

Quality Assessment Results of Riparian Vegetation Biodiversity Field Manual for RiverHealth Biomonitoring

The results of the quality assessment of the field guide book were carried out by material experts, media experts, *peer reviewers*, biology teachers and SMA N 1 Cangkringan students. The assessment was carried out using an instrument in the form of a questionnaire. The overall assessment results can be seen in Figure 2.

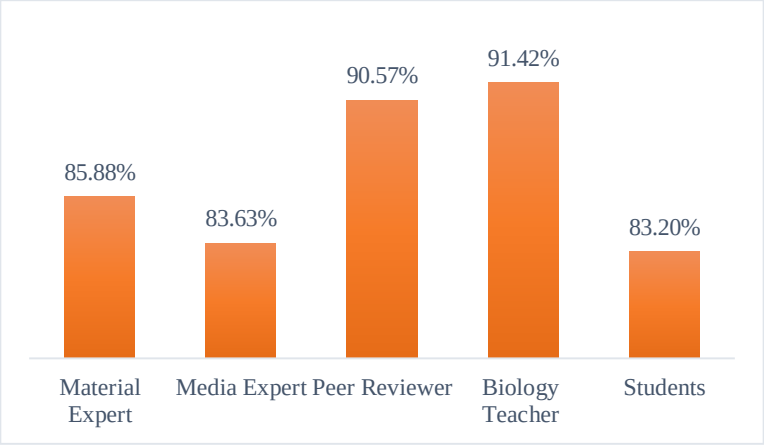

Figure 2. Percentage Quality of Riparian Vegetation Biodiversity Field Manual for River Health Biomonitoring

Conclusion

The biodiversity of riparian vegetation in Sungai Kuning and Tambak Bayan recorded108 plant species from 47 families. The Riparian Vegetation Biodiversity Field Guide for River Health Biomonitoring was developed by adopting the *Riparian Habitat Assessment* (RHA) and using the ADDIE stages (*analysis, design, development, implementation, evaluation)* with limited to ADDE, without implementation. The Riparian Vegetation Biodiversity Field Manual for River Health Biomonitoring is suitable

for use. The quality of the field guide book in order is from material experts 85.88% (Very Good), media experts 83.63% (Very Good), *peer reviewers* 90.57%, (Very Good), biology teachers 91.42% (Very Good), and students 83.20% (Very Good).

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