The International Journal Research Publication's
ISSN:2251 1563
Research Journal of Science & IT Management

Simple Method to Evaluate of River Quality based on Riparian Vegetation Bioindicator

Abdulkadir Rahardjanto,
Department of Biology Education, University of Muhammadiyah Malang,
&
Haryoto Kusnoputranto,
Department of Environmental Health, Faculty of Health and Environmental Study Program, and Environmental Science Study Progam, Post Graduate Program, University of Indonesia.
&
Dwita Sutjiningsih,
Department of Civil Engineering, Civil Engineering Faculty, University of Indonesia
&
Francisia SSE Seda
Department of Sociology, Social and Politic Faculty, University of Indonesia

ABSTRACT
As a source of water, river is very important to be maintained and preserved, both its quantity and quality, because for almost all activities of the Indonesian people do require clean water primarily as a source of drinking water. Up to now, there is no monitoring of riparian vegetation in the upper watershed conservation as a sustainable river management. The purpose of this research is to develop a conservation model in upper watershed of Brantas River based on riparian vegetation bioindicator, to realize sustainable river management. This study used survey method to observe riparian vegetation as bio-indicators of river environmental quality. The research was done by exploring physic and biology aspects of the Brantas River's environmental conditions. The result of this research showed that riparian vegetation diversity with Order 61 plants, 71 familia and 188 species shows good diversity. Riparian vegetation in terrestrial ecosystems is an important zone to regulate the flow of the movement of nutrients and energy. Important Value Index of riparian vegetation was more than 10% represented as vegetation phytosociology was quite good. The main constituent of ecosystems Riparian were *Lithocarpus sundaicus*, *Engelhardia spicata*, *Eucaliptus alba*, *Omalanthus giganteus, Pinus merkusii*, *Rouvolfia serpentina*, *Melastoma candidum*, *Oplismenus compositus, Pennisetum purpureum*, *Polygonum barbatum*, *Rouvolfia serpentina*, *Rubus molucanus*, *Rubus rosaefolius*, *Tetrastigma dichotomum*, and *Tithonia diversifolia*. As whole, based on riparian vegetation, Brantas River's quality was in a good condition.

Keywords: Watershed, riparian vegetation, bioindicator, sustainable river conservation.

Introduction

Brantas River is the second longest river in Java that crosses Batu Malang, East Java, Indonesia. The river have springs in Sumberbrantas Village that derived from water storage of Mt. Arjuno. Like most rivers in Indonesia, initially Brantas River is a source of water used for various public purposes, for example, to shower, toilet, wash clothes, and irrigate the fields. But nowadays, the river has experienced a heavy environmental pollution due to household waste pollution and hotels waste pollution . This requires monitoring of the quality of the river in order to overcome the problem of water pollution caused by the river ecosystem damages.

Basically, an ecosystem is the result of interaction between plants sub-systems, animals sub-systems, and microorganism sub-systems with abiotic factors such as air, water, minerals, and soil around it, as a single functional unit, whereas humans as an integral part of the ecosystem. Riparian vegetation is a plant sub-system that grows on the river banks. Riparian vegetation that shade the river has a direct relationship with temperature and photosynthesis in the river. The result will affect the

availability of energy in aquatic ecosystems and the dissolved oxygen content in the water (Li, 2012). Patterns of species abundance and distribution of riparian vegetation can be used as a reference in the health review of the river (Bunn *et al.,* 1999).

River health is strongly influenced by environmental condition of the river ecosystem. At first, the river ecosystem damage is caused by the micro and macro habitat destruction. This kind of damages will cause damage to entire river's ecosystem. On a good river ecosystem, there are natural vegetation on the banks, orderly. Herbicide pollution in the river was responded by this vegetation significantly. Thus, monitoring of riparian vegetation as a bioindicator of river quality is an important thing to do. In addition, the vegetation on the bank can serve as an aquatic organisms sources of energy (Abbel, 2002). In turn, reduced in plant species caused by habitat decreasing will give bad impact to river's durability and self recovery capability. The mindset of river restoration is needed in conservation, because it restore the river ecosystem in long term (Young, 2000). This study aims to determine the quality of the upper Brantas River based on riparian vegetation bioindicator.

Methodology

1. *Research method*

This study used survey method to observe riparian vegetation as bioindicators of river's quality. The research was done by exploring physic and biology aspects of the Brantas River's environmental conditions. Physic aspects consist of river substrate, while biology aspects consist of the number of the species, relative density average, absolute density, relative and absolute frequency, dominance, Important Value Index, diversity, and evenness.

Relative density is the ratio of the density of riparian vegetation-i to the total number of all vegetation species, as follows Cox formula (Cox, 2002); Plant dominance can be calculate with Simpson dominance index formula (Magurran, 1988); Diversity index of riparian vegetation using Shannon dan Wiener method (Magurran, 1988); Evenness formula as follows Brower & Zar (1990).

The plant diversity function in ecosystem is very important, because we can see position of the community structure of each respective group of organisms on the environment in which they live, as in Table 1.

Table 1 Community structure and Categories based on Shannon-Wiener index

Diversity index (H')	Community Structure	Categories	Scale
< 0.60	Not Stable	Very bad	1
0.61 – 1.2	Fair Stable	Bad	2
1.21 – 1.8	Stable	Fair	3
1.81 – 2.4	More Stable	Good	4
> 2.41	Stable	Very good	5

2. *Research location*

This research carried out in the upper Brantas River watershed, which includes three villages: Sumberbrantas, Pandanrejo, and Torongrejo villages. Each village consists of three observation stations.

3. *Population and samples*

The population in this study were all riparian vegetation that live in the Brantas River. Bioindicator study variables in this research were this following independent variables: Forests, Agriculture, and Settlements. Forest area was presented by Sumberbrantas vegetation. Agricultural area was presented by Pandanrejo vegetation, while urban area as settlement were represented by Torongrejo vegetation. Vegetation samples of this quantitative reseach was collected by random

sampling. The dependent variables includes river substrate, riparian vegetation density and relative density, riparian vegetation frequency and relative frequency, riparian vegetation dominance, Riparian vegetation importance value index, Riparian vegetation diversity and evenness. While bioindicator analysis was performed by identifying riparian vegetation species, abundance, community structure and composition, importance value index, and species diversity index. Riparian vegetation biotic sample selection is done transversely to the line of the river and repeated three times in each Riparian zone on each side of the river. In addition, the expansion of the longitudinal continuous sampling performed for an overview of the results of the Riparian vegetation.

Result and Discussion

An easily implemented and low cost river ecological health monitoring by communities, typically using a biological indicator, mainly with easily observed bioindicator as vegetation. Vegetation that grows and develops adjacent to streams in the watershed has a special term called Riparian vegetation. Riparian definition is quite varied in the literature and there is no single definition to define it (Fischer *et al.,* 2000). Origin of the word comes from the Latin Riparian *riparius* which can be freely interpreted river and only refers to the land adjacent to streams or life that exist in the area (Colwell, 2007; Colwell *et al.,* 2008; Ilhardt, 2000). Riparian in the literature describe the vegetation adjacent to rivers, lakes, and other water systems with different designations.

Position of Riparian vegetation in terrestrial and aquatic ecosystems is an important zone to regulate the movement of nutrients and energy flow (Holmes, *et al.,* 2005). Riparian vegetation has several important functions in the ecosystem (1) give an effect on the quantity, quality, and organic matter (*Allochtonous* input) on the waters of the river (Gonçalves, *et al.,* 2006; Ilhardt & 2000), (2) control the structure and composition of aquatic plant communities , (3) serves as a water temperature regulator, (4) stabilize cliffs and river banks, (5) regulate the flow of river water, and (6) the nutrients input buffer and sediment from upstream (Holmes, 2008; Holmes, *et al.,* 2005). (7) animal habitats and (8) Recreation (Colwell, 2007). Water quality is highly relied on the Riparian vegetation function as a water's quality guard (Gonçalves, *et al.,* 2006). Some recent studies emphasize the importance of this Riparian vegetation on river water ecosystems. Riparian Vegetation in the upstream region will affect the waters beneath it, ranged between 60-80% (Holmes, 2008; Holmes, *et al.,* 2005). With the variation of the rainy and dry seasons and organic matter, this input variations will affect the availability of detrivivor food resources that will ultimately affect the density of these organisms. The existence of a source of energy that comes from the Riparian vegetation will also be utilized by periphyton, macroinvertebrates, fish, and other aquatic organisms (Barbour and Gerritsen, 1996; Barbour, *et al.,* 1996; Benstead, 2003; Gonçalves, *et al.,* 2006)

As riparian vegetation habitat, structure and morphology of the soil becomes one of determining the diversity of vegetation that live in the area. The texture of the soil in the study area based on the USDA classification as in Table 2 below.

Table 2. Soil texture on research location based on USDA clasification (USDA,1987)

No	Village name	Observed station	Soil texture	
			Upper	Lower
1	Sumberbrantas	Station I	Silt	Sandy clay
		Station II	Silt	Sandy clay
		Station III	Loam	Loamy sand
2	Pandanrejo	Station I	Silty clay loam	Silty clay loam
		Station II	Silty clay loam	Silty clay loam
		Station III	Silty clay loam	Silty clay loam
3	Torongrejo	Station I	Loamy sand	Loamy sand
		Station II	Loamy sand	Loamy sand
		Station III	Loamy sand	Loamy sand

Vegetation condition in the study area can reflect the quality of the energy sources in the watershed ecosystems that affect aquatic ecosystems. The existence of terrestrial vegetation in the area of energy input into the form of coarse organic matter and fine particulate organic matter (Ziglio *et al.,* 2006). Riparian vegetation types that exist along the river forming a specific community. These vegetations are influenced by environmental characteristic in the study area such as water flow rate, the basic structure of the river, and soil fertility (Lamont, 2001). Riparian vegetation cover on the river ecosystem can guarantee the supply of energy into the waters of the river. Extensive vegetation canopy cover in the study area indicates that not many human activities that affect the Riparian vegetation can reduce biological diversity. Characteristics of river health condition is reflected in the following table 3 below

Table 3. Characteristics of Substrate River at Study Sites

No	Parameters	Sumberbrantas	Pandanrejo	Torongrejo
1	*Substrate covering in littoral zone (riverside):* - Good category (A): More than 50% of the substrate are suitable for invertebrates and diatom colonies life; There are some of rotten woods in water and stable rock substrates with various sizes. - Fair category (B): 10-50% condition is stable substrate; some parts of the substrate is disturbed, eroded or on the moved from the river - Bad category (C): stable substrate condition less than 10%; habitat for invertebrate and diatom colonies are very little and very unstable	Good (A)	Good (A)	Fair (B)
2	*Riverbank substrate is mud buried*: – Good category (A): Less than 25% of rocks is buried or covered by fine mud; rocks can be removed easily from the bottom of river - Fair category (B): 25-75% of substrate is buried in fine mud; rock need to be pulled to lift it from the bottom of river - Bad category (C): More than 75% of substrate is buried in the fine mud; rocks must be taken out to lift it from the bottom of river.	Good (A)	Fair (B)	Fair (B)

3	*Sediment deposition* -Good category (A): Less than 50% riverbed substrate is affected by sediment deposition -Fair category (B): fair of the new substrate deposition such as gravel, sand, and mud; 50-80% of it are affected by new sedimentation accumulated in the bend of the river -Bad category (C): A lot of fine particles sediment; more than 80% of bedriver substrate continues to turn, the river suffere silting up due to excessive sediment	Good (A)	Good (A)	Fair (B)
4	*Substrate in the river* -Good category (A): The bottom of river consists of a mixture of riverbed material with various sizes -Fair category (B): The bottom of river consists of silt or clay entirely -Bad category (C): The bottom of river consists of hard clay, sandstone, large stone slabs, large rocks, or sand entirely.	Good (A)	Good (A)	Bad (C)

Phytosociology quantitatively describe the condition of the Riparian vegetation with some key parameters. Some important parameters in the analysis of the Riparian vegetation structure and community are individual density, diversity, species evenness, and dominance (Pitchairamu *et al.,* 2008). Dominance of species was obtained by calculating important value index (IVI), by summing the relative density, relative covering, and the relative frequency. The most dominant species has higher important value. Riparian vegetation and other phytosociology Important Value Index analysis in this study is shown in Table 4.

Table 4. Phytosociology Riparian Ecosystem of Upper Watershed Brantas River

No	Parameters	Reseach sites		
		Sumberbrantas	Pandanrejo	Torongrejo
1	Number of species	99	72	126
2	Relative density average	100	100	100
3	Absolut density	14.15	6.6	10.05
4	Relative frequency	100	100	100
5	Absolut frequency	51.17	13.83	51.17
6	Dominance	21.37	2.84	9.80
7	Important Value Index	28. 85	20.31	9.38
8	Diversity	19.56	12.66	17.54
9	Evenness	0.40	0.95	0.54

Ecosystem characteristics such as biodiversity is one key word in discussing the ecosystem. Diversity can be seen at the level of genes, individuals, and ecosystems. Diversity refers to the variations that exist in all animal and plant species, communities and ecosystems in terrestrial habitats, freshwater and marine (USAID, 2005). At the individual level, the diversity is at the species level. In a forest habitats for example, the diversity can be obtained from various kinds of plants that live in these habitats. Likewise, the presence of various types of animals that complement this ecosystem. Important value

index (IVI) is an important parameter to assess overall significance of the species taking into account the position of the species in the vegetation.

Table 5. Important Value Index of Riparian Vegetation Ecosystems in Study area

No	Species	Familia	Important Value Index
1	*Acanthus ilicifolius* L.	Acanthaceae	8.73
2	*Acasia decurens* (Wendl.) Willd	Mimocaceae	1.00
3	*Adenostemma parviflorum* (Bl.) DC	Asteraceae	1.35
4	*Aeschynanthus angustifolius* (Bl.) Steud	Gesneriaceae	1.88
5	*Aleurites moluccana* (L.) Wild.	Euphorbiaceae	0.97
6	*Amaranthus spinosus* L.	Amaranthaceae	5.02
7	*Angiopteris avecta* L.	Marattiaceae	5.66
8	*Artemisia vulgaris* L.	Asteraceae	25.34
9	*Axonopus compressus* (Swartz) Beauv.	Poaceae	50.87
10	*Bidens pilosa* L.	Asteraceae	14.49
11	*Blumea balsamifera* (L.) DC	Asteraceae	5.00
12	*Boerlagiodendron palmatum* (Zipp. Ex Boerl.) Harms	Araliaceae	7.82
13	*Bridelia tomentosa* Bl.	Euphorbiaceae	7.30
14	*Brugmansia suaveolens* (Humb. &Bonpl. ex Willd) Bercht. & Presl.	Sonanaceae	5.96
15	*Caliandra brevipes* Bth.	Mimocaceae	5.94
16	*Calliandra haematocephala* Hassk.	Mimocaceae	3.10
17	*Centella asiatica* (L.) Urb	Apiaceae	47.44
18	*Cestrum parqui* L'Herit	Solanaceae	20.48
19	*Chingia ferox* (Blume) Holttum	Thelypterydaceae	3.71
20	*Cinhcona ledgeriana* (Howard) Moens	Rubiaceae	5.43
21	*Clerodendrum serratum* L.	Verbenaceae	8.69
22	*Coffea arabica* L.	Rubiaceae	4.40
23	*Colocasia esculenta* (L.) Schott	Araceae	1.97
24	*Commelina nudiflora* L.	Bromeliaceae	43.08
25	*Crassocephalum crepidioides* (Benth.)S.Moore	Asteraceae	3.64
26	*Curculigo capitulata* (Lour.) O.K.	Hypoxidaceae	4.79
27	*Curculigo orchiodes* Gaetrn	Hypoxidaceae	1.04
28	*Cyathea gigantea* (Wall. ex Hook.) Holttum	Cyatheaceae	2.53
29	*Cyperus compresus* L.	Cyperaceae	23.65
30	*Cyperus kyllingia* Endl.	Cyperaceae	3.34
31	*Cyphomandra betaceae* (Cav.) Sendt.	Solanaceae	1.50
32	*Dahlia rosea* Cav.	Asteraceae	1.81
33	*Davallia trichomanoides* Bl.	Davalliaceae	2.60
34	*Debregeasia longifolia* (Burm. f.) Wedd.	Urticaceae	17.86
35	*Dendrocalamus asper*L.	Poaceae	3.84
36	*Diospyros javanica* Bakh.	Ebenaceae	0.33
37	*Drymaria cordata* (L.) Willd.ex. R.&S.	Caryophyllaceae	42.31
38	*Elastostoma reticulatum* Wedd.	Urticaceae	24.14
39	*Eleocarpus angustifolius* Bl.	Eleocarpaceae	9.77

No	Species	Familia	Important Value Index
40	*Engelhardia spicata* Lech.ex Bl.	Juglandaceae	60.56
41	*Eucaliptus alba* Reinw	Myrtaceae	13.92
42	*Eupatorium inulifolium* H.B.K	Asteraceae	51.77
43	*Eupatorium riparium* Regel	Asteraceae	70.93
44	Ficus sp1	Moraceae	10.37
45	Ficus sp2	Moraceae	12.37
46	*Fragrarea fragrans*	Loganiaceae	5.74
47	*Freycinetia banksii* (A.Cunn.)	Pandanaceae	8.01
48	*Hoya cinnamomifolia* Hook	Apocynaceae	7.61
49	*Impatiens balsamina* L.	Balsaminaceae	6.05
50	*Imperata cylindrica* L.	Poaceae	11.48
51	*Ipomoea batatas* L.	Solanaceae	0.16
52	*Ipomoea* sp.	Solanaceae	22.28
53	*Ricinus communis* L.	Euphorbiaceae	1.32
54	*Dendrocnide sinuata (Blume) Chew*	Urticaceae	1.34
55	*Kylinga monocephala* L.	Cyperaceae	2.29
56	*Lantana camara* L	Verbenaceae	17.32
57	*Lithocarpus sundaicus* (Blume) Rehd., J. Arn. Arb.	Fagaceae	16.29
58	*Macropanax dispermus* (Bl.)O.K.	Urticaceae	3.47
59	*Magnolia blumei* Prantl	Magnoliaceae	2.53
60	*Manihot utilissima* L.	Euphorbiaceae	3.63
61	*Melastoma candidum* D. Don	Melastomataccae	19.93
63	*Musa acuminata* Colla	Musaceae	6.70
64	*Musa paradisiaca* L.	Musaceae	2.76
65	*Omalanthus giganteus* Z.&M.	Euphorbiaceae	29.74
66	*Oplismenus compositus* (L.) Beauv.	Poaceae	30.97
67	*Passiflora capsularis* L.	Passifloraceae	10.80
68	*Pennisetum purpureum* Schumacher	Poaceae	35.28
69	*Persea americana* L.	Lauraceae	0.49
70	*Physallis angulata* L.	Solanaceae	7.32
71	*Pinanga coronata* (Blume ex Mart.) Blume	Arecaceae	1.83
72	*Pinus merkusii* Jung et de Vriese	Pinaceae	17.56
73	*Plantago mayor* L.	Plantaginaceae	5.31
74	*Polygonum barbatum* (L.) Hara	Polygonaceae	30.64
75	*Ricinus communis* L.	Euphorbiaceae	8.85
76	*Rouvolfia serpentina* (L.) Benth. ex Kurz	Apocinaceae	18.21
77	*Rubus molucanus* L.	Rosaceae	16.94
78	*Rubus rosaefolius* J.E. Smith	Rosaceae	29.94
79	*Rumex obtusifolius* L.	Polygonaceae	6.45
80	*Pennisetum purpureum* Schumacher	Poaceae	25.83
81	*Saurauia pendula* Bl.	Saurauriaceae	5.62
82	*Schefflera actinophylla* (Endl.) H.A.T. Harms	Araliaceae	9.80
83	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	4.63
84	*Smilax glauca* L.	Smilacaceae	6.37

No	Species	Familia	Important Value Index
85	*Solanum americanum* Miller	Solanaceae	0.99
86	*Strobilathes crispus* (L.) Bl	Acanthaceae	0.00
87	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	2.26
88	*Taraxacum officinale* Wiggers	Asteraceae	1.93
89	*Tetrastigma dichotomum* (Bl.) Planch	Vitaceae	34.66
90	*Tithonia diversifolia* (Hemsley) A. Grey	Asteraceae	49.92
91	*Toona sureni* (Blume) Merr.	Meliaceae	4.25
92	*Tremma orientalis* (L.) Bl.	Achantaceae	34.82
93	*Turpinia sphaerocarpa*	Staphyleaceae	7.98
94	*Urticaceae*	Urticaceae	15.73
95	*Wedelia biflora* (L.) DC	Asteraceae	9.27
96	*Xanthosoma atrovirens* C. Koch. & Bouche	Araceae	4.91
97	*Xanthosoma violaceum* Schott	Araceae	9.91

Result and Discussion

Number of species is a quantitative measuring that most widely used in view of vegetation in an area. The relative abundance of a species is one of the factors that can affect to diversity of species in an ecosystem. Abundance of species are quite large in area studies suggest a good relationship between biotic and abiotic factors that still good in this area. Riparian ecosystem that has approximately 1% from total area, likely have disturbances from some factors, in addition to flooding, development of the agricultural and recreation areas, and so on. Riparian ecosystem disruption will cause the extinction of the species that present in the zone. Extinction species will happen when the habitat not support any longer to species life in ecosystem.

Role of riparian vegetation in terrestrial and aquatic ecosystems are to regulate nutrients and energy flow (Holmes *et al.,* 2005). Longitudinal interaction (*i.e.* transport of organic matter along the waters), lateral interactions (*i.e.* transfer of organic matter stored on riparian vegetation zone), and vertical inputs (example: leaves litter and twigs in water) associated with time, will regenerate organic matter dynamics in terrestrial ecosystems and consequently will affect the productivity and retention of organic matter in the water.

Degradation of riparian vegetation may due to various reasons, among others: The damages due to wind, fire, erosion and flood, pests and diseases, livestock grazing, and human activities (Colwell, 2007; Zogaris, 2009). Human agricultural activities will also affect Riparian vegetation quality. It will reduce the size of Riparian vegetation and even eliminate it because of the expansion of agricultural land around the river. This human activity will affect to loss of species that found in Riparian areas, reduce the water covering tree, facilitate erosion, give impact on river sedimentation, improve water turbidity, reduce dissolved oxygen in the water, and finally increase the temperature of the river.

In order to understand the biodiversity that exists in nature such as how much diversity of a species, how it disperse, what important role in the environment it has, quantitative measurement are needed, and compare it with biological quantity, consisting of discrete components in space and time. These measurements can be in genes, species, population, and community levels. Measurements can be manifested in how many taxa found in that area and shows the richness of species as well as measures the species evenness at the habitats.

Riparian diversity is a result of interaction of environmental factors with biological component in the area. Plant diversity has correlation with the environmental conditions. Higher diversity reflects the support of environmental factors to organism which live and breed in that area. Various types of vegetation live in the upstream of Brantas River, such as herbs, shrubs, and tree. Each plant has a

specific niche that appropriate to the species and indicate harmonization abiotic factors such as temperature, humidity, light, pH, and their biotic factors.

Upstream watershed ecosystem, with various components of watershed which includes vegetation, land, and river, acts as a linkages binder and dependencies between the main components of the watershed. Variety of vegetation on this system has an important role as protection against the watershed since it relates biophysicaly through hydrological cycle, as in Figure 1.

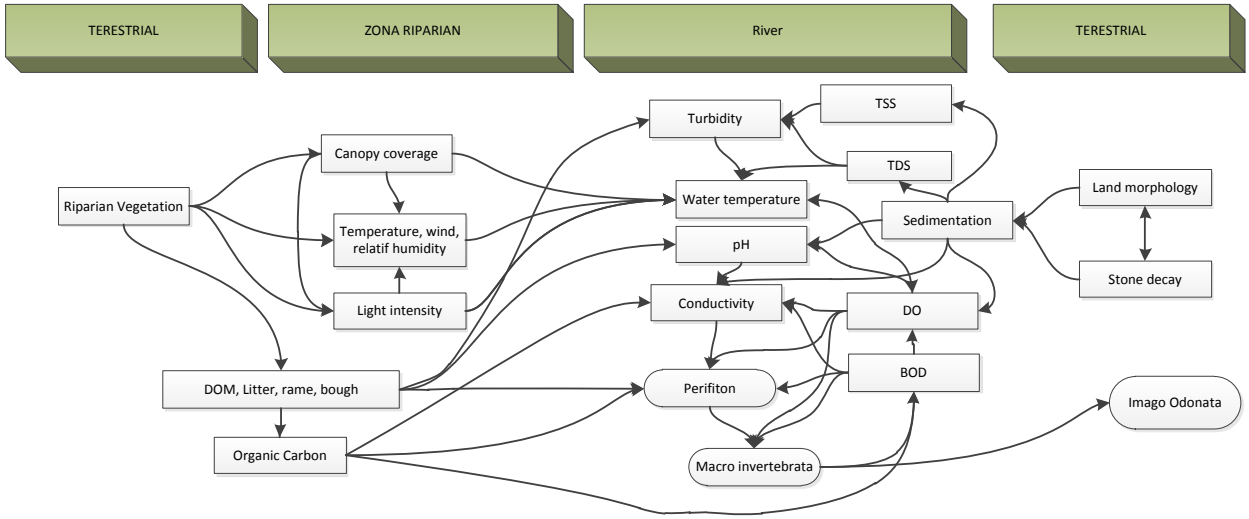

Figure 1. Interaction Model between riparian vegetation with aquatic interrelation system in river.

Vegetation as a buffer system also has a dual function, as a facilitator for rain water infiltration into the soil that will be stored in the aquifer, due to its ability in reducing water runoff coefficient (the ratio between the flow of surface water with the water flow basis), thereby reducing the risk of flooding. The diversity of vegetation in this area is a potential factor in maintaining the water system as the support of human life. Specific character of watershed is also related to the people's activities in the terrestrial area. Therefore, utilization and managing in watersheds needs good management to avoid degradation and loss of vegetation due to any disruptions.

As a major energy source in the headwaters, riparian vegetation became a source of organic carbon in aquatic ecosystems. Litter and dead organic material together with particles that exist in the riverbed to form a habitat for aquatic macroinvertebrates. Plankton that found in dead organic material is a source of energy for the organism trophic thereon. On the other hand, coverage the canopy by riparian vegetation will reduce light intensity into the waters of the river. The impact of reducing the intensity of sunlight will keep the water temperature at the optimal position for the survival of living beings in this ecosystem. interactions that occur between the subsystems in terrestrial and aquatic ecosystems depicted in Figure 1 above. Contrary, the increase in water temperature from 25 ^{0}C to 30 ^{0}C will reduce nearly 10% of dissolved oxygen waters of the river.

Conclusion

Riparian vegetation diversity served as organism habitats, river waters allochtonous input, controlling the structure and composition of aquatic plant communities, water temperature regulators, stabilizing the stream, cliff, and river banks. Important Value Index Riparian vegetation depicting phytosociology vegetation by analyzing the structure and riparian plant communities illustrate the index was still quite good with important value index (IVI) more than 10% as the main constituent ecosystems Riparian zones are *Lithocarpus sundaicus*, *Engelhardia spicata*, *Eucaliptus alba*, *Lithocarpus sundaicus*, *Omalanthus giganteus,Pinus merkusii*, *Rouvolfia serpentina*, *Melastoma candidum*, *Oplismenus compositus, Pennisetum purpureum*, *Polygonum barbatum*, *Rouvolfia serpentina*, *Rubus molucanus*, *Rubus rosaefolius*, *Tetrastigma dichotomum*, and *Tithonia diversifolia*.

The vegetation with more than 10% IVI in the upper watershed riparian zone is a type of plant that can influence the quality of the river waters. Diversity of Riparian vegetation in the watershed can be used as indicators of water quality of the area. The existence of these plants affect the structure and function of the ecosystem quality and living organisms in this ecosystem.

Acknowledgement

The author would like to thank the beneficial help and support for the completion of this paper from University of Muhammadiyah Malang, The Directorate General of Higher Education (DIKTI) Republic of Indonesia, University of Indonesia, and to the advisors for their thoughts and advice. We also appreciate the valuable technical support for identification of vegetation by Kiswojo.

References

[1] Abbel, R. (2002). Conservation Biology for the biodiversity Crisis: A Freshwater Follow Up. *Journal of Conservation Biology Vol.16 no 5. 1435-1437*

[2] Barbour, M.T. and Geritsenn, J. (1996a). Subsampling of Benthic Samples: A Defense of the Fixed-Count Method. *Journal of the North American Benthological Society, Vol. 15, No. 3. 386-391*

[3] Barbour, M.T., J. Gerritsen, G. E. Griffith, R. Frydenborg, E. McCarron, J. S.White, M. L. Bastian. (1996b). A Framework for Biological Criteria for Florida Streams Using Benthic Macroinvertebrates. *Journal of the North American Benthological Society 15. 185-211*

[4] Benstead, J.P.M.M.D., and Catherine M. Pringle. (2003). Relationships of Stream Invertebrate Communities to Deforestation in Eastern Madagascar. *Ecological Applications, 13, 1473-1490.*

[5] Brower JE, Zar JH. (1990). Field and Laboratory Methods for General Ecology. Third Editon. Dubuque, Lowa: C. Brown Publisher.

[6] Bunn S.E., P. M. Davies and T. D. Mosisch. (1999). Ecosystem measures of river health and their response to riparian and catchment degradation. *Fresh Water Biol. 41, 333–345.*

[7] Colwell, S. (2007). *The Application of the QBR Index to the Riparian Forests of Central Ohio Streams School of Environment and Natural Resources.* The Ohio State University, Ohio.

[8] Colwell, S.R., and David M. Hix. (2008). Adaptation of The QBR Index for Use in Riparian Forests of Central Ohio. *Proceedings of the 16th Central Hardwoods Forest Conference.*

[9] Cox, G.W. (2002). General ecology laboratory manual, Eighth edition. McGraw-Hill, Inc., Boston.

[10] Fischer, R.A., Chester O. Martin, John T. Ratti, Guidice, a.J. (2001). *Riparian Terminology: Confusion and Clarification,* In: and, U.S.A.E.R., Center, D. (Eds.), ERDC TN-EMRRP-SR-25, Vicksburg.

[11] Gregory S.V., F.J.S., W. Arthur McKee, and Kenneth W. Cummins. (1991). AnEcosystem Perspective of Riparian ZonesFocus on links between land and water. *BioScience Vol. 41. No 8.540-550*

[12] Gonçalves, J.J.F., Juliana Silva França and Marcos Callisto. (2006). Dynamics of Allochthonous Organic Matter in a Tropical Brazilian Headstream Brazilian *Archives of Biology and Technology Vol.49, no 6. 967-973*

[13] . Holmes, K.L., P. Charles Goebel, David M.H., Clayton, E.D., Marie E.S.D. (2005). Ground-flora composition and structure of floodplainand upland landforms of an old-growth headwater forest innorth-central Ohio. *Journal of the Torrey Botanical Society 132, 62-71.*

[14] Holmes, K.L., 2008. *The Ecology And Management Of Headwater Riparian Areas In The Erie Gorges Ecoregion Of Northeastern Ohio*, The Ohio State University.

[15] Ilhardt , B.L., Elon S. Verry, , B.J.P. (2000). *Defining Riparian Areas, Forestry and the Riparian Zone, Cooperative Forestry Research Unit*. University of MaineandManomet Center for Conservation Sciences. Ohio.

[16] Lamont, J.R. (2001). *River Conservation Strategy: A strategy to protect, conserve and enhance the natural and built heritage values of rivers in Northern Ireland and facilitate their substainable use.* Environment & Heritage Service. Belfast.

[17] Li, G., C.R.J., Kristin A. Kraseski. (2012). Modeled Riparian stream shading: Agreement with field measurements and sensitivity to Riparian conditions. *Journal of Hydrology 428–429, 142–151.*

[18] Magurran, A.E., 1988.Ecological Diversity and its Measurement. Princeton University Press. Princeton. New Jersey.

[19] Pitchairamu, M.K., N, S. (2008). Floristic Inventory and Quantitative Vegetation Analysis of Tropical Dry DeciduousForest in Piranmalai Forest, Eastern Ghats, Tamil Nadu, India. *Ethnobotanical Leaflets 12, 12. 204-216*

[20] USAID. (2005). *Biodiversity Conservation: A Guide For Usaid Staff And Partners*. In: Hess, D. (Ed.), USAID, Washington.

[21] USDA. (1987). *Soil Mechanics Level 1, Module 3, USDA Textural Classification Study Guide*, United States Department of Agriculture.

[22] Young,T.P. (2000). Restoration Ecology and conservation biology. *Journal of Biological Conservation 92 (2000) 73-83.*

[23] Ziglio, G., Maurizio Siligardi, G.F. (2006). *Biological Monitoring of Rivers Applications and Perspectives*. John Wiley & Sons Ltd, The Atrium, Southern Gate. , Chichester, England.

[24] Zogaris, S., Yorgos Chatzinikolaou and Panayotis Dimopoulos. (2009). Assessing environmental degradation of montane riparian zones in Greece. *Journal of Environmental Biology 30, 719-726.*