Exploring Riparian Vegetation Dynamics and Water Quality Assesment of Welang River – East Java

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***Abstract*-. The Welang watershed is a river that authority of East Java Province, located in three administration (Malang Regency, Pasuruan Regency and Pasuruan City). Welang catchment area from upstream to downstream is 511.60 km2, with main river length 40.09 km. The Welang river basin accommodates surface water (57 tributaries) and ground water (79 springs) in the area of Mount Arjuna (3.200 m) and Mount Bromo (2.400 m). Welang river from upstream to downstream have environmental problems. Riparian vegetation is plants that are found growing and on river banks and function as a transitional ecosystem between aquatic and terrestrial habitats. The main target in Global Strategic Plant Conservation (GSPC) is the study of plant diversity, especially in priority threatened habitats. So an initial study of riparian vegetation diversity in the Welang watershed is very important. Riparian areas are useful for maintaining river water quality and potential for environmental phytoremediation. Result this study, diversity of riparian vegetation are 171 species (upstream), 67 species (mid-stream). 37 species (downstream) and 25 species of aquatic (ex-situ) with 40 species of forest terestrial (in-situ). The Welang water quality at upstream contained organic. The middle part has the same content, no an-organic found. Meanwhile, the downstream contained an-organic.**

Keywords; Plant; Riparian; Aquatic; Terestrial; Watershad

I. INTRODUCTION

Water plays a vital role in life, and one of its main sources is river. River not only provide water for daily needs, but also support the surrounding ecosystem. In addition, rivers also play an important role in the hydrological cycle, flowing rainwater from land to the ocean [1]. A land area that is a unity with rivers and tributaries is called a river basin or commonly abbreviated as DAS [2]. The main function of DAS based on Government Regulation No. 37 Year 2012 concerning River Basin Management is to accommodate, store, and flow water from rainfall to the sea or lake naturally.

One of the strategic watersheds and its management under the authority of the East Java province is the Welang River Basin. Welang watershed is one of the rivers that passes through three administrative areas in East Java Province. The total area of the Welang river basin that passes through Malang Regency, Pasuruan Regency, and Pasuruan City from upstream to downstream is 511.60 km2 with the main river having a length of 40.09 km [3]. The Welang watershed accommodates surface water in 57 tributaries and groundwater in 79 springs located in the Mount Arjuna area (+3,200 m) and Mount Bromo (+2,400 m) [2]. The Welang river in its upstream part is a strategic conservation area. The Mount Arjuno area is included in the TAHURA R. Soerjo Forest Park while the Mount Bromo area is included in the TN Bromo-Tengger-Semeru National Park. Then before entering the middle / main stream of the Welang river, there are two ecosystems, namely: a conservation forest ecosystem, TWA Gunung Baung Nature Tourism Park as an in-situ conservation area, and a conserved vegetation ecosystem in the Purwodadi Botanic Garden as an ex-situ conservation area.

The challenge for the Welang river which is located in a strategic area and a divider between in-situ and ex-situ conservation ecosystems is its location which is also close to residential areas, agriculture and industry. So that it becomes a factor that can cause pollution in the Welang watershed, in addition to erosion and sedimentation from the upstream area. According to the research results, the carrying capacity of each part of Welang watershed has moderate to poor quality [4]. In addition, vegetation cover in the middle to downstream of Welang watershed is in very

poor condition. Whereas vegetation on the banks of the river has a very important role in supporting the surrounding ecosystem.

Vegetation on riverbanks is a transition area between aquatic ecosystems and terrestrial ecosystems that have important value and function to protect living things around the river. Vegetation in the transitional ecosystem is well known as riparian vegetation. Riparian is a wetland ecosystem with a high water level because it is directly related to aquatic or river ecosystems [5],[6]. Vegetation in riparian ecosystems is a buffer zone for water management and functions as a river embankment, which is located on the right and left of the river body. Riparian vegetation provides ecological functions as a filter for runoff water, retaining nutrients and sediment, and also being a habitat for wildlife.

The function of riparian vegetation to maintain river water quality and the existence of organisms living in rivers makes riparian ecosystems have great potential for environmental phytoremediation. Phytoremediation comes from the word phyto which means plants (Greek: phyton), and the word remediation which means repairing or cleaning something (Latin: remediare). The concept of phytoremediation is quite simple, economical, effective, and environmentally friendly, because it takes into ecological aspects in ecosystem [7], [8]. The concept of water recovery using plant technology is not yet widely known to the public, even though the phytoremediation process is relatively easy to implement, has low operational costs and abundant availability of plant vegetation. The public does not yet know much about the ecological benefits of these plants [9]. The lack of knowledge regarding information on plant potential is due to the lack of distribution of educational media that is easily accessible online [10].

In addition to its potential as a phytoremediator, riparian vegetation in the Welang river is also a supporting vegetation for conservation areas. So that vegetation along the Welang river must be well known and maintained in balance in the ecosystem. This is also in line with the objectives of the GSPC (Global Strategic Plant Conservation) to document important specific habitats and stop the loss of plant diversity. Therefore, it is necessary to conduct a comprehensive inventory of the diversity of riparian vegetation species from upstream, middle and downstream as well as in existing conservation areas and to measure water quality in Welang river - East Java. This research is very important as a form of monitoring water quality and transitional ecosystems that support conservation areas and play an important role in environmental remediation.

II. MATERIALS AND METHOD

This research used descriptive methods, which were conducted for three years, from 2021 to 2023. There were three stages of research, namely: 1. Collecting data and information from relevant agencies and literature studies. 2. Conducting a field survey and determining the location of plant diversity research, and 3. Sampling water quality along Welang river from upstream, midstream and downstream, Welang watershed map and distribution of water sampling points, can be seen in Figure 1. Monitoring of river water quality using test kits consisting of 14 parameters, and measurements for environmental quality. Data obtained from the results of literature studies and direct vegetation observations and measurements of water quality in the Welang river are presented in the results and discussions with carried out by processing and rearranging the data obtained and then presenting them in tables form or figures and in text description.

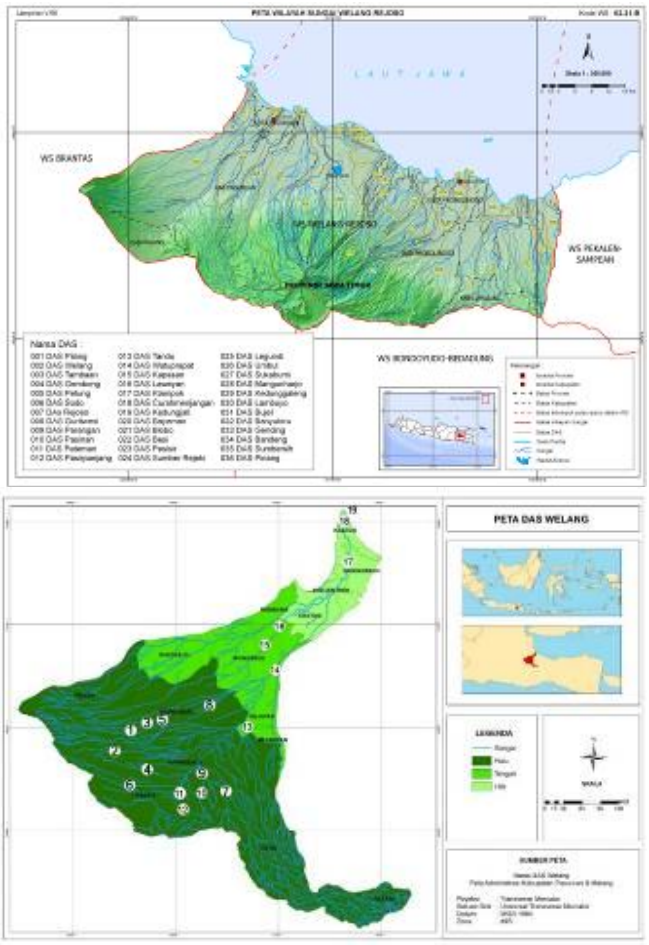

Fig. 1 Map of the Welang-Rejoso River Basin (WS) (a) and Map of the Welang Watershed (DAS) with 19 points of water quality sampling (b).

III. RESULT AND DISCUSSION

The Welang watershed has environmental degradation in the form of critical land, low land fertility, soil damage is light to moderate, and the main priority is

erosion factors [11]. The decline in land quality is in line with the decline in water quality in Welang river, due to waste disposal, domestic, agricultural and industrial waste. So that all activities communities along the Welang river affect the quality of the river water [12]. In addition, the frequent flooding problems in the Welang Watershed [13], this is certainly inseparable from the hydrological cycle that has changed due to human activities that change the landscape. Human factors that are less aware of the function of the river so that they carry out destruction, deforestation and changes in border land into settlements in river areas cause water absorption to disappear and result in flooding during the rainy season. The results study of the Erosion Hazard Level (TBE) in the Welang river [14] from very light TBE (20.88%), light TBE (38.51%), moderate TBE (17.69%), heavy TBE (15.04%) and very heavy TBE (7.88%). The occurrence of this erosion is determined by climate factors (rainfall), topography, vegetation cover and land use. So that the composition of land use in the upper Welang watershed should be managed as much as 50% of the total watershed area and plan land use according to its function.

The environmental problems and damage that occur above, such as erosion, flooding, sedimentation, soil degradation, and decreased water quality, can be overcome with natural plant-based technology, or what is known as phytotechnology. This technology can be applied by starting with baseline data on the existence of riparian vegetation along the Welang river. Riparian plants can maintain river water quality, through phytoremediation mechanisms so that river ecosystems can be naturally purified and the existence of living things in the river (river biota) makes the riparian ecosystem have great potential to be protected and maintained sustainably. The results of vegetation observations along the Welang river from upstream, middle and downstream obtained a list of the diversity of riparian vegetation species in the Welang river, as can be seen in table 1.

Table 1. List of Riparian Vegetation in Welang River.

No.	Species	Family	U	M	D
1	*Abelmoschus moschatus*	Malvaceae	✓		
2	*Achyranthes aspera*	Amaranthaceae	✓		
3	*Adenanthera pavonine*	Fabaceae	✓		
4	*Adiantum philippense*	Pteridaceae	✓		
5	*Aeschynomene elegans*	Fabaceae	✓		
6	*Ageratum conyzoides*	Asteraceae	✓		
7	*Albizia chinensis*	Fabaceae	✓		✓
8	*Albizia falcataria*	Fabaceae	✓	✓	✓
9	*Albizia lebbekoides*	Fabaceae	✓	✓	
10	*Albizia procera*	Fabaceae	✓	✓	
11	*Albizia saman*	Fabaceae			✓
12	*Alstonia scholaris*	Apocynaceae	✓		
13	*Alternanthera sessilis*	Amaranthaceae	✓		
14	*Amorphophallus variabilis*	Araceae	✓		
15	*Ampelocissus thyrsiflora*	Vitaceae	✓		
16	*Annona muricata*	Annonaceae	✓		
17	*Annona squomosa*	Annonaceae		✓	
18	*Antiaris toxicaria*	Moraceae	✓		
19	*Arcypteris irregularis*	Aspidiaceae	✓		
20	*Arenga pinnata*	Arecaceae	✓		✓
21	*Artocarpus altilis*	Moraceae	✓		
22	*Artocarpus elasticus*	Moraceae	✓		✓
23	*Artocarpus heterophyllus*	Moraceae	✓		✓
24	*Artocarpus sericicarpus*	Moraceae	✓		
25	*Asystasia gangetica*	Acanthaceae	✓		
26	*Athyrium esculentum*	Athyriaceae	✓		
27	*Averrhoa bilimbi*	Oxalidaceae	✓	✓	
28	*Avicennia marina*	Verbenaceae			✓
29	*Axonopus compressus*	Poaceae	✓		
30	*Azadirachta indica*	Meliaceae			✓
31	*Balakata baccata*	Euphorbiaceae	✓		
32	*Bambusa arundinacea*	Poaceae			✓
33	*Bambusa blumea*	Poaceae		✓	
34	*Bambusa vulgaris*	Poaceae		✓	
35	*Barleria prionitis*	Acanthaceae		✓	
36	*Barrigtonia acutangular*	Lecythidaceae	✓	✓	
37	*Belgia capensis*	Meliaceae	✓		
38	*Bidens biternate*	Asteraceae	✓		
39	*Bidens Pilosa*	Asteraceae	✓		
40	*Bischofia javanica*	Euphorbiaceae	✓		
41	*Blumea lacera*	Asteraceae	✓		
42	*Bombax ceiba*	Bombacaceae			✓
43	*Calliandra houstoniana*	Fabaceae	✓		
44	*Calopogonium mucunoides*	Fabaceae	✓	✓	
45	*Calotropis gigantea*	Asclepiadaceae	✓		
46	*Cananga odorata*	Annonaceae	✓		
47	*Canarium vulgare*	Burseraceae	✓		
48	*Capparis micrantha*	Capparaceae	✓		
49	*Carica papaya*	Caricaceae	✓	✓	
50	*Cascabela pinifolia*	Apocynaceae	✓		
51	*Cascabella thevetia*	Apocynaceae		✓	
52	*Cassia fistula*	Fabaceae		✓	
53	*Cayratia trifolia*	Vitaceae	✓		
54	*Ceiba pentandra*	Bombacaceae	✓	✓	✓
55	*Centrosema pubescens*	Fabaceae	✓		
56	*Cerbera floribunda*	Apocynaceae	✓		
57	*Cerbera odollam*	Apocynaceae	✓		
58	*Christella arida*	Thelypteridaceae	✓		
59	*Chromolaena odorata*	Asteraceae	✓		
60	*Cleome viscosa*	Capparaceae		✓	
61	*Clinacanthus nutans*	Acanthaceae	✓		
62	*Coix lacryma-Jobi*	Poaceae	✓		
63	*Commelina benghalensis*	Commelinaceae	✓		
64	*Corchorus aestuans*	Tiliaceae	✓		
65	*Cordia bantamensis*	Boraginaceae		✓	✓
66	*Corypha utan*	Arecaceae			✓
67	*Crotalaria pallida*	Fabaceae	✓		
68	*Cyathula prostrata*	Amaranthaceae	✓		
69	*Cymbopogon citratus*	Poaceae		✓	
70	*Dehaasia caesia*	Lauraceae	✓		
71	*Delonix regia*	Fabaceae	✓		
72	*Dendrocalamus giganteus*	Poaceae			✓
73	*Dendrocnide stimulans*	Urticaceae	✓		
74	*Derris elliptica*	Fabaceae		✓	
75	*Desmodium triflorum*	Fabaceae	✓		
76	*Dimocarpus longans*	Sapindaceae		✓	
77	*Diospyros cauliflora*	Ebenaceae	✓		
78	*Diospyros macrophylla*	Ebenaceae	✓		
79	*Dracontomelon dao*	Anacardiaceae	✓		
80	*Durio zibethinus*	Malvaceae	✓		

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No.	Species	Family	U	M	D
81	*Dysoxylum gaudicaudiaum*	Meliaceae	✓	✓	
82	*Elephantopus scaber*	Asteraceae	✓		
83	*Eleusine indica*	Poaceae	✓		
84	*Eranthemum pulchellum*	Acanthaceae	✓		
85	*Eucalyptus platyphylla*	Myrtaceae	✓		
86	*Euphorbia hirta*	Euphorbiaceae	✓		
87	*Excoecaria agallocha*	Euphorbiaceae			✓
88	*Ficus copiosa*	Moraceae	✓		
89	*Ficus hispida*	Moraceae		✓	
90	*Ficus racemosa*	Moraceae	✓	✓	✓
91	*Ficus septica*	Moraceae	✓		
92	*Ficus variegata*	Moraceae	✓		✓
93	*Ficus virens*	Moraceae	✓	✓	
94	*Galinsoga quadriradiata*	Asteraceae	✓		
95	*Gigantochloa apus*	Poaceae		✓	✓
96	*Gigantocloa aster*	Poaceae		✓	
97	*Gliricidia sepium*	Fabaceae	✓		
98	*Gmelina arborea*	Verbenaceae	✓	✓	✓
99	*Hedyotis corymbose*	Rubiaceae	✓		
100	*Hibiscus tiliaceus*	Malvaceae			✓
101	*Hiptage benghalensis*	Malpighiaceae	✓		
102	*Homalomena pendula*	Araceae	✓		
103	*Hopea sangal*	Dipterocarpaceae	✓		
104	*Hypobattrum peutialicum*	Liliaceae		✓	
105	*Imperata cylindrica*	Poaceae	✓		
106	*Ipomea asiatica*	Convolvulaceae		✓	
107	*Ipomoea fistulosa*	Convolvulaceae	✓		
108	*Jasminum multiflorum*	Oleaceae	✓		
109	*Jatropha multifida*	Euphorbiaceae	✓		
110	*Kigelia Africana*	Bignoniaceae	✓		
111	*Kleinhovia hospital*	Sterculiaceae	✓	✓	
112	*Kyllinga monocephala*	Cyperaceae	✓		
113	*Lagerstroemia thorelii*	Lytracheae	✓		
114	*Lannea coromandelica*	Anacardiaceae	✓	✓	
115	*Laportea aestuans*	Urticaceae	✓		
116	*Leea indica*	Leeaceae	✓		
117	*Leucaena leucocephala*	Fabaceae	✓	✓	✓
118	*Litsea glutinosa*	Lauraceae	✓		
119	*Ludwigia octovalvis*	Onagraceae	✓		
120	*Magnolia candolii*	Magnoliaceae	✓		
121	*Mangifera indica*	Anacardiaceae	✓	✓	✓
122	*Manilkara akras*	Sapotaceae	✓	✓	
123	*Maranta arundinacea*	Marantaceae	✓		
124	*Melanolepis multiglandulosa*	Euphorbiaceae	✓		
125	*Melicoccus bijugatus*	Sapindaceae			✓
126	*Melochia umbellate*	Sterculiaceae	✓	✓	
127	*Meremia emerginata*	Convolvulaceae	✓	✓	
128	*Microcos tomentosa*	Euphorbiaceae	✓		
129	*Microlepia speluncae*	Dennstaedtiaceae	✓		
130	*Mikania cordata*	Asteraceae	✓		
131	*Mimosa borealis*	Fabaceae		✓	
132	*Mimosa pudica*	Leeaceae	✓		
133	*Moghania strobilifera*	Fabaceae	✓		
134	*Moringa oleifera*	Moringaceae	✓		✓
135	*Mucuna propruena*	Fabaceae		✓	
136	*Muntingia calabura*	Elaeocarpaceae	✓	✓	✓
137	*Murdannia nudiflora*	Commelinaceae	✓		
138	*Musa paradisiaca*	Musaceae		✓	
139	*Nauclea orientalis*	Rubiaceae	✓	✓	
140	*Nephrolepis radikal*	Dryopteridaceae	✓		
141	*Octomeles sumatrana*	Datiscaceae	✓		
142	*Oplismenus burmanni*	Poaceae	✓		
143	*Oplismenus compositus*	Poaceae	✓		
144	*Orophea enneandra*	Annonaceae	✓		

No.	Species	Family	U	M	D
145	*Oxalis barrelieri*	Oxalidaceae	✓		
146	*Paederia scandens*	Rubiaceae	✓		
147	*Parkia speciosa*	Fabaceae	✓	✓	
148	*Parkia timoriana*	Fabaceae	✓		
149	*Paspalum conjugatum*	Poaceae	✓		
150	*Passiflora foetida*	Passifloraceae	✓	✓	
151	*Pennisetum purpureum*	Poaceae	✓	✓	
152	*Peperomia pellucida*	Piperaceae	✓		
153	*Persea americana*	Lauraceae	✓	✓	
154	*Phyllanthus niruri*	Euphorbiaceae	✓		
155	*Phyllanthus reticulatus*	Euphorbiaceae	✓		
156	*Pinus merkusii*	Pinaceae	✓		✓
157	*Piper cubeba*	Piperaceae	✓		
158	*Pisonia aculeate*	Nyctaginaceae	✓		
159	*Pisonia umbellate*	Nyctaginaceae	✓		
160	*Pogonantera paniceum*	Polytrichaceae		✓	
161	*Pogonatherum marceum*	Poaceae	✓		
162	*Polyalthia littoralis*	Annonaceae	✓		
163	*Polyalthia longifolia*	Polytrichaceae		✓	
164	*Pometia pinnata var. javanica*	Sapindaceae	✓		
165	*Pragmites orca*	Poaceae		✓	
166	*Protium javanicum*	Burseraceae	✓		
167	*Pseudelephantopus spicatus*	Asteraceae	✓		
168	*Psidium guajava*	Myrtaceae	✓		
169	*Psydrax dicoccos*	Rubiaceae	✓		
170	*Pteris cretica*	Pteridaceae	✓		
171	*Pteris ensiformis*	Pteridaceae	✓		
172	*Pterocarpus indicus*	Fabaceae		✓	
173	*Pterospermum diversifolium*	Sterculiaceae	✓		
174	*Rhizophora mucronate*	Rhizopjoraceae			✓
175	*Ricinus communis*	Euphorbiaceae		✓	✓
176	*Rivina humilis*	Phytolaccaceae	✓		
177	*Roystonea regia*	Arecaceae	✓		
178	*Schizostachyum tiaminsi*	Poaceae		✓	
179	*Schleichera oleosa*	Sapindaceae	✓	✓	
180	*Scoparia dulcis*	Plantaginaceae	✓		
181	*Semecarpus heterophylla*	Anacardiaceae	✓		
182	*Senna spectabilis*	Fabaceae	✓	✓	
183	*Sida acuta*	Malvaceae	✓		
184	*Sonneratia alba*	Lythraceae			✓
185	*Spathodea campanulate*	Bignoniaceae			✓
186	*Spermacoce articularis*	Rubiaceae	✓		
187	*Spigelia anthelmia*	Loganiaceae	✓		
188	*Sporobolus diander*	Poaceae	✓		
189	*Stenochlaena palustris*	Blechnaceae	✓		
190	*Sterculia coccinea*	Sterculiaceae	✓		
191	*Sterculia foetida*	Sterculiaceae	✓		✓
192	*Swietenia macrophylla*	Meliaceae	✓		✓
193	*Synedrella nodiflora*	Asteraceae	✓		
194	*Syzygium cumini*	Myrtaceae	✓		
195	*Syzygium formosum*	Myrtaceae	✓		
196	*Syzygium littorale*	Myrtaceae	✓	✓	✓
197	*Syzygium pycnanthum*	Myrtaceae	✓		
198	*Tabernaemontana sphaerocarpa*	Apocynaceae	✓		
199	*Tagetes erecta*	Asteraceae	✓		
200	*Tamarindus indica*	Fabaceae			✓
201	*Tectaria aurita*	Dryopteridaceae	✓		
202	*Tectona grandis*	Verbenaceae	✓	✓	✓
203	*Terminalia catappa*	Combretaceae			✓
204	*Theobroma cacao*	Sterculiaceae	✓		
205	*Tithonia diversifolia*	Asteraceae	✓		
206	*Trema orientalis*	Cannabaceae		✓	
207	*Tridax procumbens*	Asteraceae	✓		
208	*Urena lobatta*	Verbenaceae		✓	

No.	Species	Family	U	M	D
209	*Voacanga grandiflora*	Apocynaceae	✓		
210	*Wedelia biflora*	Asteraceae	✓		
211	*Wrightia tomentosa*	Apocynaceae	✓	✓	
212	*Xylocarpus granatum*	Meliaceae			✓

U (upstream), M (midstream), D (downstream).

One of the characteristics of riparian vegetation is that it can adapt to wetland environments and serves as a habitat for terrestrial and aquatic biota. This vegetation is habitually found to include shrubs, herbs, bushes, and trees. The diversity of riparian vegetation species in the Welang river is described into three river sections, namely: upstream, middle, and downstream.

In the upstream part of the Welang River, 171 species of riparian vegetation have been inventoried. In the upstream riparian vegetation, it is divided into two, namely agricultural riparian vegetation and natural riparian vegetation. Agricultural riparian vegetation is a species of plant that is planted in the riparian zone, such as: rice, corn, chocolate, and various species of fruit plants. While natural riparian vegetation is a plant that grows naturally on the banks of the river such as grass, weeds, bushes, bushes and trees of various other species [6].

In the middle part of the Welang River, there are 67 species of riparian vegetation. Of the 67 species found, they come from 29 families, with the largest family being Fabaceae with 12 species. In general, the riparian vegetation in the middle part of the Welang river has tree habitus and understory vegetation / ground cover. The number of riparian vegetation species in the middle part is less than in the upstream part, because the conditions are in residential areas, factory/industrial areas and agricultural land/ fields that are very close to human activities [15].

In the downstream of the Welang River, 37 species were recorded. Of the 37 species, they came from 21 different families, with the dominant families being Fabaceae and Moraceae. Riparian vegetation found in the downstream of the Welang river generally has tree habitus, which includes mangrove vegetation (13.5%), coastal vegetation (10.8%), and lowland vegetation (75.7%). If observed from the upstream, middle and downstream which are increasingly towards the river mouth, there is less diversity of species. This is due to the increasingly dense population or the destruction of land functions along the river as built-up areas and also in the estuary area which is the final destination of water flow which on its journey is mixed with waste / contaminated with pollutants that are discharged into the river environment [5].

From the description above, it shows that the dynamics of riparian vegetation in the upstream Welang river are 171 species, the middle part 67 species and the downstream part 37 species. When viewed the total number of Welang river from upstream, middle and downstream has 275 vegetation. However, this does not take into account duplication or the presence of the same species in each part of the river. So if an inventory is carried out based on species, there are 212 riparian vegetation species. The Species found in all parts of the Welang river, from upstream, middle and downstream are: Albizia falcataria (Fabaceae), Ceiba pentandra (Bombacaceae), Ficus racemosa (Moraceae), Gmelina arborea (Verbenaceae), Mangifera indica (Anacardiaceae), Muntingia calabura (Elaeocarpaceae), Syzygium littorale (Myrtaceae), and Tectona grandis (Verbenaceae). Of the 212 riparian vegetation species as listed in table 1, only 8 species of vegetation are found throughout the Welang river. The eight species have tree habitus and are terrestrial vegetation types.

Table 2. List of Terestrial Plants in In-Situ Conservation Area (TWA G.Baung)

No.	Species	Family
1	*Acacia auriculiformis*	Fabaceae
2	*Albizia chinensis*	Fabaceae
3	*Annona muricata*	Annonaceae
4	*Anthocephalus cadamba*	Rubiaceae
5	*Artocarpus elasticus*	Moraceae
6	*Artocarpus heterophyllus*	Moraceae
7	*Artocarpus sericicarpus*	Moraceae
8	*Arytera litoralis*	Sapindaceae
9	*Butea monosperma*	Fabaceae
10	*Calliandra calothyrsus*	Fabaceae
11	*Canthium glabrum*	Rubiaceae
12	*Ceiba pentandra*	Malvaceae
13	*Chrysophyllum caimito*	Sapotaceae
14	*Dendrocalamus asper*	Poaceae
15	*Durio zibethinus*	Malvaceae
16	*Ervatamia sphaerocarpa*	Apocynaceae
17	*Ficus hispida*	Moraceae
18	*Ficus septica*	Moraceae
19	*Firmiana malayana*	Sterculiaceae
20	*Gigantochloa apus*	Poaceae
21	*Gliricidia sepium*	Fabaceae
22	*Gmelina arborea*	Lamiaceae
23	*Jacaranda obtusifolia*	Bignoniaceae
24	*Kleinhovia hospital*	Malvaceae
25	*Lannea coromandelica*	Anacardiaceae
26	*Mallotus peltatus*	Euphorbiaceae
27	*Mangifera indica*	Anacardiaceae
28	*Melanolepis multiglandulosa*	Euphorbiaceae
29	*Microcos tomentosa*	Euphorbiaceae
30	*Parkia speciosa*	Fabaceae
31	*Parkia timoriana*	Fabaceae
32	*Persea americana*	Lauraceae
33	*Psidium Guajava*	Myrtaceae
34	*Pterocymbium javanicum*	Sterculiaceae
35	*Reutealis trisperma*	Euphorbiaceae
36	*Senna spectabilis*	Fabaceae
37	*Streblus asper*	Moraceae
38	*Swietenia macrophylla*	Meliaceae
39	*Syzygium polyanthum*	Myrtaceae
40	*Tectona grandis*	Lamiaceae

The 8 species of riparian vegetation found on the Welang river are terrestrial vegetation. If these species are compared with the natural terrestrial vegetation that grows in the TWA G.Baung area, there are 40 species, as can be seen in table 2, The species taht found in both in the Welang river and those in the TWA G.Baung is Tectona grandis (Verbenaceae). Meanwhile, if the species of aquatic vegetation found in the Welang river are compared with those in the KKI Purwodadi Botanic Gardens collection, there are 25 species, as can be seen in table 3, then only two species were found same, namely Coix lacryma-jobi (Poaceae) and Ludwigia octovalvis (Onagraceae).

Table 3. List of Aquatic Plants in Ex-Situ Conservation Area (KKI KRPurwodadi).

No.	Species	Family
1	*Acanthus ilicifolius*	Acanthaceae
2	*Achanthus montanus*	Acanthaceae
3	*Acorus calamus*	Acoraceae
4	*Actinocorpus grossus*	Arecaceae
5	*Ceratophyllum demersum*	Ceratophyllaceae
6	*Ceratopteris thalictorides*	Adiantaceae
7	*Coix lacryma-Jobi*	Poaceae
8	*Cyperus alternifolius*	Cyperaceae
9	*Echinodorus radicans*	Alismataceae
10	*Ipomea aquatica*	Convolvulaceae
11	*Lasia spinosa*	Araceae
12	*Lemna minor*	Araceae
13	*Limnocharis flava*	Alismataceae
14	*Ludwigia octovalvis*	Onagraceae
15	*Nelumbo nucifera*	Nelumbonaceae
16	*Neptunia plena*	Fabaceae
17	*Nymphaea alba*	Nymphaeaceae
18	*Nymphaea rubra*	Nymphaeaceae
19	*Nymphaea stellata*	Nymphaeaceae
20	*Pistia stratiotes*	Araceae
21	*Pontederia cordata*	Pontederiaceae
22	*Sagittaria lancifolia*	Alismataceae
23	*Salvinia molesta*	Salviniaceae
24	*Thalia geniculate*	Marantaceae
25	*Typhonodorum lindleyatum*	Araceae

The Welang River is located in a strategic hydrological area in East Java Province. The Welang watershed is located in the middle of the Bromo Tengger Semeru Arjuno Biosphere Reserve (CB BTSA). Where the upstream part is a row of hills / mountains from TAHURA (Forest Park) R. Soerjo and TN. BTS (Bromo Tengger Semeru National Park) and the main Welang river upstream passes through in-situ and ex-situ conservation areas and as a boundary between the two areas. The in-situ conservation area is the TWA G.Baung (Nature Tourism Park) and the Scientific Conservation Area (KKI) of the Purwodadi Botanic Garden which is an ex-situ plant conservation area. The strategic position of the Welang watershed can be seen in Figure 2.

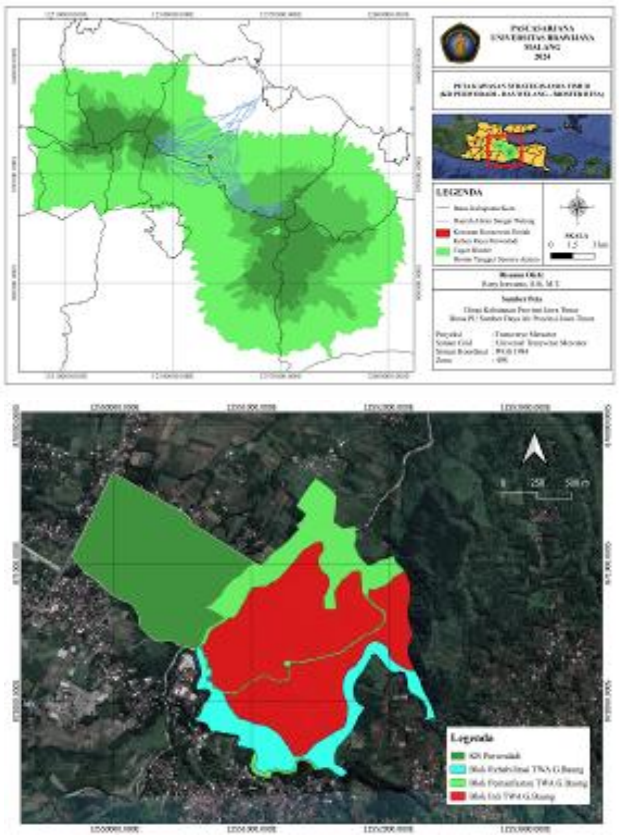

Fig. 2. Map of Strategic Area in DAS Welang (CB BTSA) (a) and Map of Conservation Areas In-Situ and Ex-Situ (b).

The results of riparian vegetation exploration along the Welang eiver from upstream to downstream obtained a total of 212 species. When compared with the inventory data of terrestrial vegetation species in the TWA G.Baung area of 40 species and also aquatic vegetation species in the KKI Purwodadi Botanic Gardens of 25 species.

However, the reality today is that riparian vegetation has experienced a lot of damage and pollution due to human activities that threaten its sustainability. In addition, the lack of attention from area managers or stakeholders and the change of riparian areas into built-up areas, has caused the loss of riparian functions in holding back rainwater flow and other ecological functions. The reduction or even loss of riparian vegetation diversity can be prevented by efforts to restoration, reforestation or revegatation of river boundaries, especially in the upstream area which hydrologically is a forest area that acts as a catchment area.

Therefore, the plants in both conservation areas are very suitable to be used as a recommendation species for habitat restoration in river ecosystems, especially in the Welang Watershed. Other, in the enrichment of riparian vegetation that low vegetation diversity in the downstream part of the Welang River. The existence of riparian vegetation in Welang watershed is very important for monitoring and knowing the condition of the river water

environment. In general, riparian vegetation with tree habitus is important in strengthening river transects, protecting riverbanks from erosion and flooding, where the root structure is strong in gripping the soil and the sturdy stem shape and crown architecture support wildlife habitat. Meanwhile, to maintain the quality of river water, riparian vegetation, especially those with aquatic habitats, can be an indicator as well as a phytoremediator in filtering pollutants and restoring river water so that its quality remains good.

Welang River monitoring efforts were also carried out, considering that the 40.09 km long Welang River only has three monitoring stations, namely Station 1 in Purwodadi, brown water conditions and lots of vegetation. Station 2 in Selowongko, brown water conditions, lots of sediment, and little vegetation. Station 3 in Dhompo, water conditions with little sediment, and not much vegetation. Overall, the condition of the Welang River from the upstream is not very good in terms of physical quality [2]. So direct monitoring of the water quality of the Welang River was carried out at 19 locations from the upstream, middle and downstream, the results of water quality monitoring are presented in Table 4.

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Table 4 Water Quality Parameters for the Upstream, Middle and Downstream Welang River Basin.

Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Ph	6.98	7.15	7.89	6.83	7.28	7.76	7.95	7.85	8.16	7.59	7.65	7.5	7.76	6.98	6.89	6.75	8	8	8.3
TDS	84	53.5	95.5	107.5	121	132.5	76.5	110.5	139.5	152	127	151.5	127.5	128.5	150.5	208.5	214	234	1000
Water Temperature	27.6	24.45	28.2	28.2	28.3	31.55	24.35	29.7	28.7	29.34	28.35	27.9	29.55	30.1	28.5	58.7	34.6	31.5	31.5
Hardness	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Alkalinity	180	80	120	80	80	80	80	120	180	120	120	120	160	80	120	120	100	120	120
Free Chlorine	0	0	0	0	0	0.5	0	0	0.5	0.5	0	0.5	1	0.5	0	0	0	0	0
Total Chlorine	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2	1
Nitrate	100	100	100	100	100	100	100	100	100	100	100	100	25	50	25	25	0	0	0
Nitrite	20	20	20	20	20	20	20	20	20	20	20	20	5	10	5	5	0	0	0
Fluoride (Fluor)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	1
Iodine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyanuric Acid	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0
Carbonate Root	20	20	0	20	0	20	20	20	20	20	20	20	20	20	20	20	0	0	0
Free Bromine	0	0	0	0	0	1	0	0	1	1	0	1	1	0.5	0	0	0	0	0
Iron	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	3	1
Lead	50	50	50	50	50	50	20	50	50	50	50	50	20	50	50	20	30	30	30

In the upstream part of Welang there are 12 points, number 1-12 points location which are divided into two streams, 6 points from Mount Arjuna and 6 points from Mount Bromo. While the middle part of Welang there are 4 points, which are at location points number 13-16, and the downstream part there are 3 points, at location points number 17-19.

The results of monitoring the pH parameters in the Welang river from upstream to downstream range from 6.7-8.3 which is still considered normal water pH conditions. If the water pH decreases to become acidic or increases to become alkaline, it can disrupt the balance of the aquatic ecosystem. The pH concentration affects the level of water fertility because it affects the life of microorganisms. Acidic waters tend to cause fish death, as does a pH that is too alkaline. Meanwhile, monitoring the water temperature parameters ranges from 24.35°C-34.60°C which is still considered normal, this is because if the temperature exceeds 35°C it can cause fish death.

The results of chemical parameters obtained from the water test strip, in the upstream section contains Chlorine (Cl), Bromine (Br), Iron (Fe), Lead (Pb), Nitrate (NO3-), Nitrite (NO2-), Fluoride (F-), and Root Carbonate (CO3 2–), in the middle section predominantly has the same content as the upstream but no Iron (Fe) was found, while in the downstream section Chlorine (Cl), Copper (Cu), Lead (Pb) and Fluoride (F-) were found.

The discovery of Nitrate and Nitrite content in monitoring the water quality of the Welang river can be caused by agricultural waste. Nitrate is a nutrient for the growth of aquatic plants and algae, causing uncontrolled growth of aquatic flora, while nitrite is a toxic compound that can kill aquatic biota [16]. So if high nitrate causes blooming algae/aquatic flora, coupled with high nitrite causes the death of aquatic biota. Then if aquatic plant species are found such as Coix lacrima-jobi or Ludwigia octovalvis on the riverbanks of the Welang River, it is certain that these species are capable of restoring the river ecosystem or self-purifying river water.

Parameters related to heavy metals such as Iron (Fe) are highest in the upstream, Copper (Cu) is highest in the upstream, and Lead (Pb) is highest in the upstream and middle parts. These heavy metals in waters have an impact on aquatic organisms and humans. Heavy metals are one of the toxic pollutants that can cause death (lethal) or sub-lethal such as disrupting growth, behavior or changes in organism morphology. These heavy metals if they enter the human body are very dangerous for health [17].

Overall, the results of monitoring the water quality of the Welang River in the upstream section have experienced contamination from organic materials, which are likely to come from agriculture and settlements, in the middle section due to human activities, in addition to organic contamination, in-organic materials in the form of heavy metals were also found, which can be ascertained to come from industrial waste that is discharged into the river, so that in the downstream section which is the estuary of all organic and inorganic pollution.

IV. CONCLUSION

Riparian areas are useful for maintaining river water quality and potential for environmental phytoremediation. The diversity of riparian vegetation are 171 species (upstream), 67 species (mid-stream). 37 species (downstream) and 25 species of aquatic (ex-situ) with 40 species of forest terestrial (in-situ). The Welang water quality at upstream contained organic. The middle part has the same content, no an-organic found. Meanwhile, the downstream contained an-organic.

ACKNOWLEDGMENT

Our deepest gratitude goes to the Phytotechnology and Environmental Management Research Group (2021) who have taken initial steps of riparian research in Welang river and also the support of Water Resources Agency (Dinas PU Sumber Daya Air) East Java Province, which involved researcher in judging of IHRC (Indonesia Healthy Rivers Challenge) 2021.

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