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A COMPARATIVE STUDY OF CONTAMINATED RIPARIAN ZONE FOR ECO LANDSCAPE DEVELOPMENT STRATEGY

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ABSTRACT

The transition between terrestrial and aquatic ecosystems has been known as Riparian Zone. The riparian zone is where generally water flows rarely stagnant, which river is an intermediate plateu. Conversely, rivers, stream or lakes water flows can be stagnant in common situation. Svejcar in his article stated that as transition, riparian zone tends to have characteristics of both upland and aquatics ecosystems. Water contamination brings the effect on reforming the environment degradation whether they are directly or indirectly discharged into water bodies without adequate treatment. Various notable water rehabilitation projects in leading countries led to their substantial economic returns for many aspects by the government-led initiatives. Nature-inclusive solution has been heavily concerned for the mega projects. In which ecological landscape design can provide the ecosystem services to balance the engineering driven restoration projects. To include, the best practice management requires extended understanding of the pattern in order to allow optimum evaluation of the process relationship. This research is conducted by an explanatory method where writer observe the relevant writings and theory to evaluate riparian areas with support on both primary and secondary data. A comparison table has been conducted to determine the most optimum approach has done by three different cities in two big countries. They are Siak River, Riau, Indonesia between Citarum River in Bandung and Yangtze River in China. This comparison will explain the elements observe among the three rivers and follow by the explanatory theory that has been conducted, a best practice management for landscape design to be evaluate.

Keywords: *riparian zone, water contamination, landscape ecology, best practice management*

INTRODUCTION

Water contamination happened to be a major global problem for every developed city. Where municipal wastes are unconsciously moving through the city drain and ended up unsorted in river or ocean. Urban water problems are respectively threatening and challenging. For city-state to take this issue heavily, require evaluation process, management policy with many stake-holder involvement at all levels.

Water body can be contaminated easily depending on their concentration. An example that is commonly found is the cleaning or leaching of nitrogen compounds from fertilized agricultural land. In the other hand, municipal waste form households have been one of the major impacts to the water contamination. The water bodies such as lakes, rivers, ocean, aquifers and groundwater are contaminated and making water pollution.

Basically, contaminated groundwater source grouped into two categories. When surface water seeps through the soil, they become ground water. Based on their origin, chemical and non-chemical pollution makes contamination that enter a waterway from a single, identifiable source categorized as one point source water contamination. Where contaminations that does not originate from a single discrete source categorized as Nonpoint source water contamination. They often gathered from a large area where small amount of pollutant accumulated. While seldom in between Point and Nonpoint source identified, common example such as agricultural, storm water washed off of parking lots, roads and highways (urban runoff) make the Nonpoint source. However, because urban runoff typically channeled into

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drain system in most countries, and dispense through pipes to local water bodies, they included in Point source (Khurana, 2021).

Water Contamination Effect

Water contamination has been suggested as the prominent cause of deaths and diseases globally. Daily counted more than 14,000 people dies for this cause only. The term contamination is used to describe hazardous materials of any kind that are polluting a source of water. Sources of contamination in water include portions of human and animal waste, inappropriate disposal of chemical wastes, or inevitable natural disaster events such as naturally occurring floods and other catastrophic events, to the communal use of agricultural products such as pesticides and fertilizers (Kijne, 2005). Hazardous materials could include both biological and chemical substance. Those hazardous materials preside to human body through the water sources they use for daily activities from ponds, lakes, seas, oceans, or reservoirs. Used for drinking, shower, dishwashing, even agriculture and live stocks. There are several causes framed the contamination based on both organic and inorganic factors such as industrial waste, sewage and wastewater, mining activities, marine dumping, accidental oil leakage, burning of fossil fuels, chemical fertilizers and pesticides, urban development, leakage from the landfills and underground storage leakage (Baum, 2007).

Industries of any aspects exceed vast amount of toxical which contains chemicals and wasted pollutants where ended to damage the environment. The harm they contain such as lead, mercury, sulphur, asbestos, nitrates and many other leaked chemical. The effect they bring has reformed the environment degradation whether they are directly or indirectly discharge into water bodies without adequate treatment. To maintain the sustainability of water pollution management, it is necessary to carry out continuous evaluation at all levels and if necessary revise the water resources policy for aquifers at the regional level to the use of individual wells (Comte, 2012).

In terms for urban development, as population has grown, so has the demand for housing, food and cloth. The more cities developed, the more fertilizers use increased to produce more food. When land needed, deforestation causes soil erosion, construction activities increased, there are inadequate sewer collection and treatment, landfills formed as more garbage is produced, and definitely more materials has produced which increase in chemicals. Landfills leakage produces awful smell when huge pile of garbage liquid contaminated underground water when it rains. Later on, health problems resulted by the harmful chemicals contained in sewage water that produced by each household as the impact of urban development. Greater, they effected health concern on population through person-to-person contact when the contaminated water enter their household water supply (Rixen, 2010).

Broader development in housing demands food supplies which by means chemical fertilizers and pesticide are used by farmers (Kijne, 2005). This industrial exploitation excesive to corps protection. They are incrediably useful for the agricultural, yet harmless to the plants and animals. On rainy season, chemicals that flute with rainwater will flow down into rivers and canals. When water bodies contaminated from the effect of chemical uses, this obviously will damage the aquatic plants and animals. Cycle process will always go on when people are actually consume the water that come from the contaminated water bodies. Which can cause more severe disease.

Riparian Zone

Riparian zone has an importance much greater than their size implies. There are similarities between terrestrial and aquatic ecosystems that play an important role in enriching biota called biodiversity (Svejcar, 1997). The transition between uplands and downland (aquatic ecosystems), present significant characteristic to help the coverage of plantation life which those areas can prevent or control stream bank erosion, provide habitat for wildlife, and disputes the pollution of water to the entire chain of ecosystem area. Water and nutrients support significant plant communities in riparian land. They are usually become pack and generally denser, rapidly growing and have much more number of layers or strata. With those criteria, they perform variety of valuable functions than adjacent plant communities.

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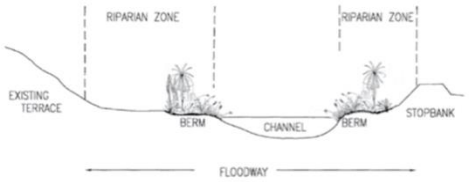

Figure 1. Variation of riparian zone width. Source: (Water and Rivers Commission, 2000)

The width of a riparian zone can vary from a few metres to tens of metres depending on topography, flow fluctuations and adjacent land uses. The width should be at least equal to the top height of trees or shrubs within the zone. The criteria, dense and variant layers of plant communities, support a healthy, native riparian vegetation. They will reduces the water temperature of aquatic habitats by shading. Once aquatic habitats (especially plant community) produces tannin, the water resulting a distinctive amber colour, which further light penetration of the water column (Water and Rivers Commission, 2000). Immediate riparian vegetation independently seek aquatic ecological processes. From small to narrow upland streams, instream ecosystem lies significant influence to larger, wider lowland rivers. The immediate riparian vegetation (native), rely heavily on inputs from upstream. It is vitally important to recognise the upstream riparian plant communities -dense, native and healthy- play a critical role in the functioning of the entire river ecosystem and produces water purifications.

The critical role covered as pollution, sediment and nutrient trapping for most contaminants/ pollutants. For other significant role, they include channel stability, flood control and habitat provision and corridors. Sediment and nutrient trapping for pollutants also called as *biofiltration*, attached particles before they reach the channel. In biofiltration, most research indicate buffer zone effect can be achieved by lush grasses and understorey plants at least 20 metres from the top of bank. With this requirement, pollutant and nutrient stripped and wider buffer zone comes naturally. Also, buffer zone is also effective when the flow of water is shallow and steady (Svejcar T. , 1997).

River Channel Stability

In order to reduce the risk of erosion which naturally occur during the high tide in riparian area, vegetations play a big role for the streambank. Firstly, streambanks can be protected by the root systems of shrubs and trees (riparian vegetation) to reduce erosion. By reinforcing and increasing cohesion of the soil, also provides a protective surface matting. Though bank failure sometimes occurs due to heavy saturated soil, riparian vegetations' roots can use water in the banks and increase the drainage of the soils to prevent the failure. Second, to get stability, connecting layers of litter and debris to increase the roughness of the channel can be adjusted. Furthermore, by slowing down the flow and reducing the capacity of the water flow to erode and transport sediment (Environment Canterbury Regional Council, 2011).

In addition, the benefits of having stable channels, a healthy river embankments from riparian areas that are naturally vegetated, can reduce the force, height and volume of floodwater at certain points along the river flow. By allowing the water to spread horizontally, the floodplain will follow the flow of the flood road so that it crosses the floodplain. Hence, the naturally vegetated riparian must be carefully planned to get a high productivity and diversity of plant community. They can be found in a natural existing riparian area and already provides valuable habitat for a variety fauna to support diverse and abundant communities.

Not little of many the reduction in native vegetation cause the minor of habitat provision. Increasing large distance between remnant habitats, riparian corridors serve a vital function in allowing the movement of flora and fauna. In between the remnants the communities found their habitat provision in their own right. While biofiltration can prevent sediment and nutrients from healthy vegetation and biota from entering rivers, Large Wood Debris (LWD) and lively vegetation also provide shelter, feed and provide spawning habitat for birds, fish and invertebrates (Environment Canterbury Regional Council, 2011).

Rehabilitations Opportunity

The understanding on existing landscape function in particular, water bodies are exceled through the engineering driven project process and design. To manage an improvement from time to time, mega cities has considered an ecological approach to be involved in the solution. Under-researched design to develop an increament inch by inch

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evaluated through every aspect in the government and stake holder agreement.

Ecological landscape development strategy demands a long-life cycle process on environment related ecosystem services (Gret-Regamey, 2016). Integration of different segments (nature, structure, design and regulation) contrast a societal demand on having a modestly good environment for them to function in everday life. Consequently, there is a slight chance to achieve a stable environment for everyone good cause.

However, engineers and planners are keen on exploring methods in modelling and planning process. In order to focus on bringing life back into the mother nature and integrated the social function to their value and culture, participatory process of multidiscipline are engaged. Engineering driven solution like how European cities has done for many cases of flood mitigation are the pioneer for an exemplary development strategy. Years after, nature-involve design process accumulate the most breakthrough rehabilitation method for river/water bodies development. Malaysia, Singapore, Korea and China have done a lot of good to follow project sample for many landscape designers. The habitation for every site should be precause and alarmed, because what we are dealing with is topography and local biodiversity.

RESEARCH METHOD

This research is conduct by explanatory method where the writer did a relevant reading on related literature to compile and linked the theory and find a result of the best practice as the writer did a comparative study for three samples from primary and secondary data. The three samples studied and compared from each of their elements that suit to requirements of a healthy riparian zone. Those elements such as Spatial condition, Biodiversity and ecosystem, Issues and Development action.

The study on how a healthy riparian zone can affect development on semi urban to urban area be proven by analyzing selected from both advance and developing cities. Primary data collected on Siak River, Indonesia as the dominant research object, while to compare, secondary data gathered for Yangtze river, China and Citarum River, Indonesia.

DISCUSSION AND SOLUTION

Spatial Condition

Siak River, Pekanbaru, Indonesia

One of the deepest river in Indonesia which has a depth of 20-30 meters, and length of 300 kilometers, belongs to Siak River located in Pekanbaru City, Riau Province, Indonesia. It stretch through four administrative area which are Rokan Hulu, Bengkalis, Siak and Kampar District. Therefore, Siak River has become a specific river to Riau Province. It carries history of Malay territorial, brings life to the origin of Pekanbaru city and has been the heart of Riau development.

Figure 2. Siak river, Indonesia. Source: Wikipedia, 2019

Siak river has been the main corridor transportation throughout Riau province and cause a rapid economic growth. Followed by the great size of its own, Siak River can be a main corridor for transportation of logistic, agricultural, and industrial. It requires large ships to be accomodate because the depth and width. No only local regions but also to iternational region, because Siak river ended to Malacca Strait which just right Malaysia Peninsula. So that the business has been achieved through Siak River which cause a rapid economic growth to Riau Province.

However, the anthropogenic impact has increased along with changes in land use. Municipal and industrial waste disposal cannot be reduced and accumulated due to rapid economic growth and mining waste, over the last decades. Due to the coastal interior and dense population, oxygen consumption increases and this results in the emergence of organic and inorganic pollution. These pollutants are predominantly particles transported out to the ocean, and make them a major threat to estuarine and coastal environments due to their potential toxicity. Whereas rivers in Indonesia only flow 2% of the global land area, and the existing pollution has brought 20-25% of sediment exports to the oceans (Siegel, 2008).

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Citarum River, West Java, Indonesia

Almost 12,000 kilometers square of Citarum River Basin covers 13 administrative areas of districts and cities. It has 3 large dams, Saguling, Cirata and Jatiluhur. Those dams actively provide hydroelectric power generation and serve local irrigation (I, 2015).

In 2008, total population within the catchment was just over 11 millions. They majority live along the river banks which their manual is use the river water body for domestic purpose including drinking water. Over the years, without obeying government restriction on municipal and sewage management in household, in addition, lack of education and awareness on preserving natural condition of the riverbank, Citarum has heavily contaminated from various activities within the catchment (Sinaga, 2013).

The West Java Provincial Government has made efforts to implement various community-based programs to improve the condition of water resources that focus on the Citarum river basin and educate the public awareness as the resource owners to be more responsible yet they have come to failure in over the last decades.

Figure 3. Greenpeace protest on government concern to Citarum River condition. Source: Greenpeace home website, 2019

It is recorded that 300 types of organophosphorus and carbamate pesticide compounds affect the agricultural, industrial and household sectors to be used communally and result in the discovery of chemicals in fish, especially in the liver, which are harmful to humans (consumers) and biota in the ecosystem (Djuangsih, 1993).

Yangtze River, China

The Yangtze River is recorded as a river that drains one-fifth of the land area of Greater China and is home to a third of the country's population. With topographical conditions as the longest river in Asia and the third longest in the world. As the largest water system in China, the Yangtze river has important historical, economic and cultural value to the country.

Since Yangtze river hold the recognition as the most unique and significant ecosystem, they varies biota and attracts tourism aspect. Yangtze River divided into five defined areas of the basin (riverhead, upper reach, middle reach, loer reach and estuary). Nearly 60% species are endemic fishes. In the upper reach, there are 97 endemic species which indicating that the distribution intensively occurs there. Meanwhile, common species on the other defined areas are less then 25% of the total fish species number in the basin. The Chinese paddlefish *(Psephurus gladius)* and Chinese sucker *(Myxociprinus asiaticus)* mainly distributed and could be found in all the three reaches (Ye, 2011).

In the last half century, this country's population has more than doubled and become heavily concentrated along the major river valleys. WWF has established Siberian crane, Yangtze alligator, Yangtze river dolphin, and Yangtze finless porpoise become endangered species and almost extinct.

Figure 4. Municipal and industrial sewage contaminated Yangtze river. Source: WWF home website, 2019

Their extinct affected mostly by slop erosion, sedimentation, industrial pollution, and municipal sewage. Slop erosion and sedimentation happens due to disturbance of natural process, and drastic reduction of wetland division. A wetland division cause degradation to water quality and wetland landscape which led the reduction in their capacity for absorbing high water levels. Also a large-scale deforestation in the upriver has destroyed the 'sponge' function of the soil which increased flooding (Kijne, 2005).

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Ecological landscape design approach

BMP (Best Management Practice) uses to control, store and/or treat strom water runoff from developed areas for the purpose of reduce flooding and remove pollutants. The measurement taken while maintaining or enhancing environment quality. Environment quality can be enhance while adapting the storm water/ run off management and providing a general, multi purpose riparian buffer with variant design of grass, shrubs and trees between the normal bank level and cropland (Anbumozhi, 2004). This require landscape design hierarchy to understand their function and ecological engineering calculation.

Storm water management facilities, through best management practice, serves multiple uses such as:

1. sustainable land use
2. nutrient retention rate in riparian forest (varying width, slope, soil type and vegetation)
3. the measurement can help to monitor the changes in pollution level (responsible to alterations in forest buffer zone)

Comparison Study

Table 1. Riparian areas comparative study

	Case of Study		
	Yangtze River	Citarum River	Siak River
Riparian Character	Length: 6,300 km Meander	Length: 297 km Meander	Length: ± 300 km Meander move by cutting the outside bank and building a point bar
Special Biodiversity	Home to Yangtze Dolphin	Endemic fishes for daily consume	River mangrove
Main Issue	- Sediment erosion - Contaminated by toxic	Contaminated by toxic	- Sediment erosion - Greenbelt loss - Contaminated by toxic
Issue Background	- Dye factory dumping - House & Industrial sewage	- Dye factory dumping - House & Industrial sewage	- Timber & latex industry dumping, sewage, and shipping - Oil palm plantation, leaking, and shipping - Latex leaking
Urban density	Very dense	Very dense	Moderate
Historical Value	Archeological site, Buddhist Temples, Historical village.	Historic folklore to home people	Siak Sri Indrapura Castle
Watershed System	Small river tributaries	3 catchment areas	Small river tributaries
Chemical density contain	High	Very High	High
Activities	Yangtze Cruise (Tourism)	Agriculture, Daily fishing	Timber & Palm oil shipping, Latex industry
Problem solving	Engineering approach	Environmental & Engineering approach	In plan by government
Changes after development	- Artificial riparian zone - Treated surface water - The reservoir can holds back 20 billion tons of water - About 60500 acres of farmland, orchards flooded - About 1000 archeological sites submerged - About 100 towns were submerged	- In progress - Upper Citarum Basin slowly recovered	–

Source: Writer, 2019

The three rivers that already discuss earlier, has a similar spatial condition and issues background. As shown on the table above, they serves similar elements such as the rivers located in a high density development city, valueable to culture and historical engagement, and same issue background which contaminated due to sewage. The river that is very specific to one region, could possibly restore only by engineering approach. This approach usually valued ecological aspect less to get an immidiate impact.

CONCLUSION & RECOMMENDATION

Conclusion

Subsequent initiatives, city-state engagement, society demand, and breakthrough exploration are the keys to the multi layer process. An ecological landscape engineering and hydrologic assesment can be a suitable management practice for a watershed scale development strategy (Gret-Regamey, 2016). Results may vary in different spatial conditions, versatile.

The overview of ecological landscape development strategy can be conventional regarding that elements considered still a nature-driven solutions. Believing in concept requires iterative and coorporation from the needs and idea of living in a healthy urban area.

While there are boundaries between nature and engineering driven purpose, an examination and planning process are worth the study to many develop cities in Indonesia. The country has potential-risk to obey from government for heavily concerning water contamination especially in the riparian areas. Socio-economic and cultural aspects of the country can enhance the planning and the natural habitat can offer more robust landscape design.

Recommendation

A coherent understanding of the important roles of a healthy riparian area through limited study on objects can be adjusted accordingly by explanatory data from this paper. The data collection offers some significant thinking on strategies and scenarios to convey the best design for each spatial condition. While not all repercussions of these data can mitigate the best infrastructure, a proposed green landscape strategy can be an example for those who are trying to enhance their development strategies.

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