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Pollution Control Strategy on the Boyolali Gandul River Borderline: SWOT Analysis

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***Abstract*---*River borders are green belts that should be free from permanent, non-permanent or semi-permanent buildings. However, people still use many river borders to build houses. Gandul River is one of the rivers with borderland use that violates regulations. This research aims to analyze the quality of polluting elements and SWOT analysis for strategies for controlling pollution. The research was carried out using a mixed methods approach in the form of quantitative and descriptive. Descriptive research analyzing water quality as an abiotic element was assessed using water quality parameters (temperature, TDS, TSS, pH, total coliform, and DO) and a qualitative culture analysis will be carried out using SWOT (Strengths, Weaknesses, Opportunities, Threats) on 60 respondents who live in Gandul River border as the main respondent. The polluting elements in the Gandul River are coliforms that reached >16,000 during 2021-2023. Strategies in efforts to control buildings on the Gandul River border include firm action to implement government and regional regulations, providing education, and assisting the community with relocation efforts. Land use on the Gan-dul River border causes an increase in the total coliform value so efforts are needed to relocate.*
Keywords*---*Gandul River, pollution, SWOT, water quality.

Introduction

Environmental conditions can influence the state of public health in an area or place of residence. Water is the source of life for everything, health is a state of the body that is free from disease, and the two types of water and health are interrelated and interact with each other (Mishra, 2023).

Rivers are one component that is a source of water for life. Rivers are a source for all sectors of human life and a home for other organisms (Singh et al., 2020). In human activities, rivers are a source of irrigation for rice fields, industrial and household activities (Afrad et al., 2020). Some of these human activities often generate waste from either point-source pollution or non-point-source pollution (Adu & Kumarasamy, 2018).

Non-point source pollution is a source of pollution that is not definitively localized. Sources of this pollution usually come from suburban areas, big cities, rural homes, agriculture, and livestock. These pollutant sources are spread from several areas and do not directly pollute water bodies (Zou et al., 2020). Usually, these pollutants first pollute groundwater or water channels (open or closed water channels), which then end up in water bodies, such as

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rivers and the sea. One example is that waste from human activities can pollute river ecosystems, which are a place for other organisms (Häder et al., 2020). One of the problems of river pollution is the presence of buildings and waste disposal in river border areas.

Excessive land use on river borders also occurred in the Gandul River, Boyolali Regency. The Boyolali Regency Government, through regional spatial planning regulation number 8 of 2019, gives regulations for urban areas of at least 15 m to the right and left, while rural areas are given regulations of at least 50 m to the right and left. River borders naturally function as barriers to river flow so that they do not overflow and can be used as a place for animals to breed. However, due to the inappropriate use of river borderland for the construction of permanent, non-permanent or industrial settlements, natural plants will be lost, so the function of preventing erosion will be lost (Borges et al., 2023). It will also increase the load of pollutants entering the river.

This research took the case of the Gandul River, located in the southern region of Boyolali Regency and passes through Musuk, Mojosongo, Teras, and Sawit Districts. Based on initial surveys in the field, several violations of river border land use were found, namely residential buildings very close to rivers or within river borders (violating regional regulations), especially in urban areas. This condition is assumed to be due to an increase in the need for land in both the residential and industrial sectors, resulting in a need for more availability of open land. Apart from settlements that contribute to wastewater, development violations can be seen in several industries, including large industries and the dumping of waste directly into rivers. Apart from that, people often throw rubbish carelessly on river borders (Satapathy & Kanungo, 2018).

Methods

The research was carried out using a mixed methods approach in the form of quantitative and qualitative descriptive. The descriptive method with a quantitative approach in this research was used to describe the border conditions and water quality of the Gandul River, Boyolali Regency, from March 2021 to 2023, taken together with the Boyolali Regency Environmental Service (DLH) at points 1) upstream of the Gandul River in the Village. Sukabumi, Cepogo coordinates: South: 07"30'59.g", East: 110"30'53.2". 2) middle of the river in Gerit Village, Mojosongo coordinates: South: 07"55'55. 8, East: 110"62'44.03". 3) downstream of the Gandul River in Tegalrejo Village, Sawit coordinate point South: 07"34'42.8, East: 110"40'09.8".

The impact of water quality as an abiotic element will be assessed using water quality parameters, including temperature, TDS, TSS, pH, total coliform, and DO). The quality standard used is PP No. 22 of 2021, using the SNI 6989. 57-2008 test-taking procedure included field equipment used polyethene sample bottles, grab samplers, TDS/EC meters, DO meters, pH meters, questionnaires, and writing instruments. The field materials used were H2SO4, HNO3, HCl, and 4% Formaldehyde as sample preservatives. The laboratory equipment used is glass equipment, a spectrophotometer, a set of titration tools, an AAS (Atomic et al.), an incubator, a COD reactor, a vacuum pump, a fiber-glass filter, an oven, a microscope, an HPLC (High-Performance Liquid Chromatography), hot plate magnetic stirrer and a set of distillation equipment. Based on observation and monitoring, a culture assessment was carried out using a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis (Sammut-Bonnici & Galea, 2015).

Results and Discussion

Visualization of land use and water quality in the Gandul River Borderline

Figure 1 is a visualization of land use on the Gandul River borderline, Boyolali, showing still settlements and buildings violating regulations on the river border. Only the blue color indicates the water from the river and the dark green in Cepogo are forests. Based on the data, it is known that there are at least three company building points, 12 residential points, and three building points standing along the Gandul River border.

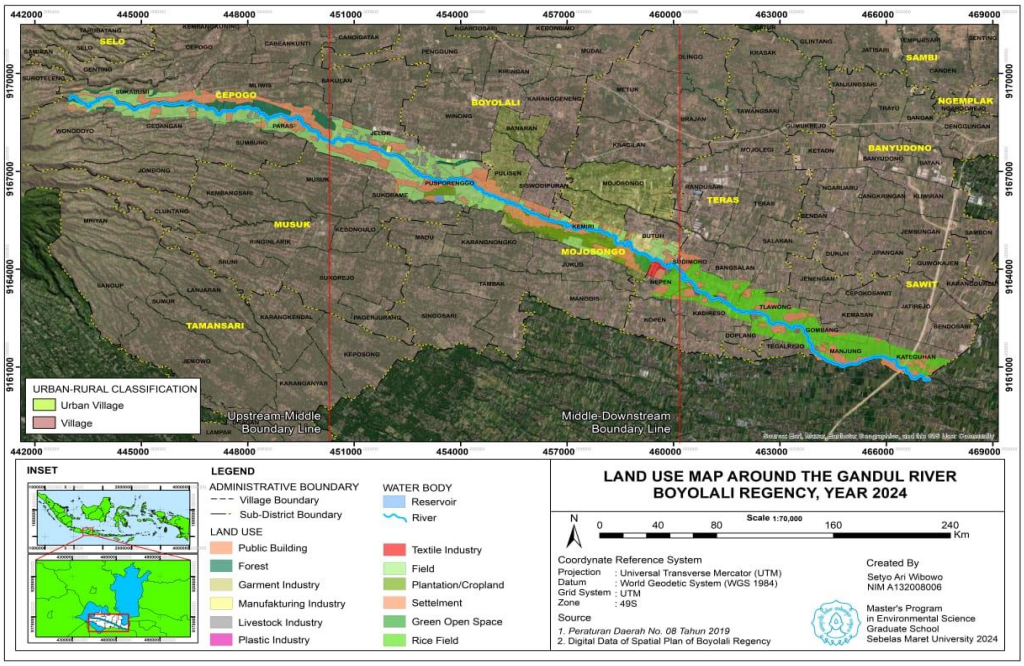

Figure 1. Visualization of land use on the Gandul River borderline, Boyolali

Water quality assessment is based on direct research and measurement of quality standards according to government policy (Pemda Boyolali, 2016) and STORET score. Water quality assessment is carried out at 3 points: upstream, midstream, and downstream for 3 years. Based on research and environmental service data for three years, it can be seen that the total coliform parameter in the middle section of the Gandul River has a value that is always high. At this point, several houses and buildings were also found in the river border area (Table 1).

Table 1
Gandul River Water Quality

Test point	Years	Parameters (quality standards)					Conclusion
		TDS (1000mg/L)	TSS (100mg/L)	pH (6-9)	Coliform (10.000)	DO (>3mg/L)	
Upstream	2021	210	7	6.8	540	4.7	appropriate
	2022	270	11	6.6	350	3.8	appropriate
	2023	92	10	6.5	130	4.2	appropriate
Midstream	2021	160	9	7.9	>16000	5.7	High coliform
	2022	190	16	7.6	>16000	3.5	High coliform
	2023	148	22	7.4	>16000	4.3	High coliform
Downstream	2021	220	8	6.4	3500	5.7	appropriate
	2022	240	17	7.3	3500	3.5	appropriate
	2023	188	21	4.0	9200	7.0	appropriate

Source: Primary data

Based on the observations and image visualization results, 60 heads of families live around the Gandul River border and two companies whose buildings partially touch the river border. This building is centered along the middle of the Gandul River. These results show that land use is uncoordinated and free from government supervision, spurring increasingly uncontrolled conversion of land into built-up areas which causes riverbank areas to experience inappropriate land use, with buildings along the right and left banks of the river (Alam et al., 2022).

This result is in line with panel research (Chakraborty, 2021), which reported that there was a disturbance on the border, a protected area of the river. This will cause problems such as the loss of protected green belt areas, prone to disasters such as floods, and even the potential to pollute river water. Apart from that, people on river banks generally

throw rubbish and household waste directly into river bodies or water (Aboyitungiye & Gravitiani, 2021). Rivers are an important source of clean water in life (Sultana, 2018).

Based on theory, rivers should be inseparable from the growth and development of a city and its population. River borders that are quite wide and have lots of plant life (flora) and animals (fauna) in them reflect healthy land use in an area. The existence of many types of flora and fauna species is a biodiversity asset that is important for the long-term sustainability of human and natural life (Raven & Wackernagel, 2020).

Based on monitoring results, it can be reported that there has been a decline in the water quality of the Gandul River in the middle section. This result is in line with regional mapping, which shows that the distribution of permanent community buildings on the river border is in the middle of the river flow. The decline in river water quality is marked by an increase in total coliforms, which should be within the quality limit of only 10,000. However, in the middle of the Gandul River, the number is >16,000 for three consecutive years.

Contamination in river water includes chemical, physical, and biological aspects that influence pH, temperature, BOD, and COD DO on the number of coliforms in river water (Seo et al., 2019). High levels of microorganisms, such as coliforms Escherichia coli, are indicators of water pollution due to domestic waste, which is the cause of the transmission of diseases (Odonkor & Mahami, 2020).

Coliform is a class of microorganisms commonly used as an indicator to determine whether a water source is contaminated because its density is directly proportional to the level of water pollution (Some et al., 2021). Coliform bacteria greatly impact human health, especially the digestive organs, and cause diseases such as diarrhoea (Rahman et al., 2021) and even death if they infect children. These coliform bacteria produce ethionine, which can cause cancer (Śmiełowska et al., 2023). Apart from that, these putrefactive bacteria also produce toxins such as indole and skatol, which can cause disease if there are excessive amounts in the body (Dimitratos et al., 2019).

The research results report that the possibility of coliform pollution is caused by ten heads of families who have the habit of defecating in the river even though they have a septic tank or channelling waste into the river, one head of family who does not have a septic tank, and livestock companies that may dispose of potential waste to grow E. coli bacteria (Kampa & Castanas, 2008; Chan & Yao, 2008).

Researchers concluded that the increase in total coliforms obtained at the middle river monitoring point was in line with a large amount of misuse of borderland in the middle of the Gan-dul River. This problem has been going on for three years and requires the role of various parties so that bacterial contamination in the river area does not spread downstream. Researchers also suggest that the government immediately take firm action against residents and companies that erect permanent or non-permanent buildings on the Gandul River border because this will have an impact on water quality and has the potential to trigger the construction of other buildings in the future if there is no firm action in regulating borderline river area (Uddin et al., 2021; Bilotta & Brazier, 2008).

SWOT Analysis

Analysis of the strategy to improve the use of the Gandul River border was presented in a SWOT Matrix, which describes how opportunities and threats from the external environment can be anticipated with their strengths and weaknesses. The SWOT matrix for the use of the Gandul River border will involve strategies targeting the government and community as follows:

Table 2
SWOT Analysis

	Strengths	Weakness
Opportunities	S/O strategy 1. There are government and regional regulations regarding prohibiting building buildings along river borders. They are supported by the majority of people who do not live on the river border. 2. Active community organizations such as Karangtaruna, RT, RW, cadres, and PKK can be fostered and empowered to become an extension of the government in providing education and teaching local communities to manage	W/O strategy 1. People who do not have a land certificate (because the land was inherited from their ancestors or given by the government) have the potential to be relocated and have a new land certificate made in a new location by stakeholders. 2. The absence of a budget and schedule for cleaning rivers can be overcome with company cooperation/corporate social responsibility and special regional budgets for community activities, especially those living around rivers so that they can be

	Strengths	Weakness
	waste. 3. Involving the government, companies, and community associations to conduct discussions, negotiations and execution regarding moving houses or cleaning rivers. 4. Making regulations and periodic mitigation for purification.	used for environmental cleanup and promoting river cleanup efforts. 3. Efforts need to be made to improve community PHBS together with the health team regarding ways to dispose of waste that has the potential to produce E.coli
Threats	S/T 1. Define the community empowerment concept and company participation in land use and water pollution control policies. 2. Establish sanctions and increase coordination in policy-making for relocating houses and buildings around river borders because some buildings were given official permits before regional regulations were updated and border areas were expanded.	W/T 1. Determine and enforce bureaucracy between the government, companies, and residents living in border areas so that they are willing to be relocated. 2. Plan and create a household waste disposal system and septic tank so it does not flow into the river. 3. To improve the performance of IPAL, government support is applied to overcome the misuse of borderland and river polluting waste.

Source: Primary data

Based on the results of the SWOT analysis taken from primary data in the form of a questionnaire related to culture and reasons for occupying borderland, it was found that the elements that became strategic points in efforts to control buildings on the Gandul River border include: (1) Control based on strong government and regional regulations, (2) Community organizations tend to be active and have the value of cooperation, it is very possible to be given the education to be willing to relocate, (3) Most of the buildings were built based on ancestral heritage without complete documentation so they have the potential to be relocated, but the government must look for new land and provide appropriate permits legal and based on the law so that people cannot return to building buildings on river borders.

The implementation and efforts to regulate buildings on river borders also certainly have challenges and require the seriousness of the parties involved. Some of the main obstacles that arise include: (1) Bureaucracy between the government, residents, and industry who own the buildings requires good strategy and cooperation so as not to cause problems, protests or strong refusal; (2) It takes quite a lot of funds to carry out relocation and make new and legal land documents. (3) Efforts are needed to monitor, maintain and create a system for disposing of household waste and sewage, which could allow contamination of the Gandul River by E coli bacteria and the like.

This SWOT analysis intends to identify factors that provide a relatively higher degree of importance than other factors. In this case, the internal factors are human resources, supervision and guidance, and information providers (Chang & Huang, 2006). Meanwhile, external factors are government support, domestic waste disposal, knowledge of waste disposal, land use, and wastewater analysis. Cross-sectoral collaboration is needed with related community health centres, local governments, and environmental health teams to carry out water mitigation and purification because, at the downstream point, bacteria have been decomposed, so it is still very possible that the water quality of the Gandul River will be returned to its function according to class 3 utilization.

Conclusions

Land use on the Gandul River border has the potential to cause pollution and geographical disturbance. Strategy points in efforts to control buildings on the Gandul River border include: (1) involving community organizations for education before relocation, (2) The government must look for new land and provide legal permits so that people cannot establish buildings on the border again.

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