Landuse culture and water quality (BOD, COD, DO) in the upper citarum river corridor

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Abstract. The culture of land use in river corridors has a major effect on water quality, especially on organic chemical parameters such as BOD, COD and DO. This complexity is the main attraction to study in depth. The objectives of this study include several points to analyze (1) the correlation between land use culture and water quality (BOD, COD and DO); (2) constructing a strategy for handling water quality pollution in the upper Citarum river corridor. The method used was a survey with a regional approach through geospatial and correlation analysis. The results obtained (1) Water quality (BOD, COD and DO) has a strong correlation with anthropogenic activities of land use culture around the river corridor such as settlements, industry, chemical fertilizer use and others. (2) Handling strategies that are tailored to the identified zones such as forest areas, built-up areas, agriculture and shrubs. Some of the research results obtained can be used as relevant references for targeted treatments to succeed in a sustainable fragrant Citarum.

1 Introduction

The existence of rivers as ecosystems is most affected or threatened by various anthropogenic pressures [1,2]. Anthropogenic pressures include activities such as household activities, agriculture, industry, tourist areas, and others. Thus, anthropogenic activities affect water bodies and result in a drastic decrease in river water quality (WQ) [3]. The decline in water quality has rendered some surface water supplies unusable for drinking, industrial, agricultural and other purposes [4]. Essentially, water is said to be clean through certain parameters to identify the quality of the water. Water quality parameters can be characterized into biological, chemical, and physical parameters [5].

Recently, the decline in the quality of surface water such as rivers based on organic chemical properties has become a critical issue [6]. Given, rivers play an important role as a source of water in our daily lives [7]. To further focus the study of this research, it is known that water quality parameters are divided into three including physical, chemical and biological. This research focuses on one parameter to be studied in more depth, which includes chemical parameters, especially organic chemistry (BOD, COD, and DO) in the Citarum river body.

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The Citarum River is the lifeblood of the community along and around its watershed [8]. Therefore, pollution control in the Citarum River is needed with the issuance of Presidential Regulation No. 15/2018 on the Acceleration of Citarum River Watershed Pollution and Damage Control [9]. Included in the strategy of handling water pollution in the river body, the research specifically specializes in modeling the relationship between land use culture and water quality focused on organic chemical parameters (BOD, COD, DO) in the river corridor area as the novelty of this research.

This scheme is packaged by visualizing the aims and objectives of this research which include (1) analyzing the empirical relationship modeling of landuse culture and quality of water on organic chemical parameters (BOD, COD, DO); (2) Strategies for handling potential river pollution in the Citarum river corridor upstream area.

2 Methods

2.1 Research Site

The research site covers the river corridor, which is defined as 1 km^2 right and left of the main Citarum river in the upstream area. The scope of the observed water quality research is limited to the river corridor with five observation point locations including Solokan Jeruk, Sapan, Dayeuh Kolot, Cilampeni Bridge, Nanjung. The five points functioned as cathment area plots as the initial center of observation for each space. For more details, it is visualized in Figure 1.

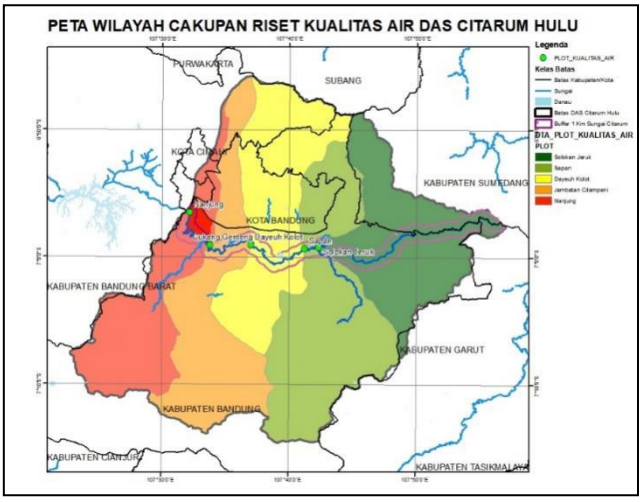

Fig 1. Research Coverage of Upper Citarum Watershed Water Quality Observation Points

2.2 Research Approach

The approach used in the research is a spatial approach with a survey method by elaborating the value of water quality, especially in organic chemical parameters and the cultural value of land use in the river corridor.

2.3 Data Collection Research

Data was collected from secondary data and primary data. Secondary data was obtained from satellite imagery between 2019-2022. Satellite images were extracted into multitemporal land use data. Observation instruments were developed to obtain data on land use conditions in the field. Primary data was obtained by measuring the water pollution of the Citarum River, especially on organic chemical parameters including BOD, COD and DO.

2.4 Data Analysis Research

The analysis used in this study is a correlation analysis through multiple regression by elaborating the cultural value of land use with the value of water quality on organic chemical parameters (BOD, COD and DO).

3 Results and discussion

3.1 Landuse Culture and Quality of Water (BOD, COD and DO)

The results of the review of organic chemical parameters based on the levels of BOD, COD and DO in the inter-space water and empirical cultural use zoning in the Upper Citarum area are presented in Table 1.

Table 1. Land Use Zoning and Annual Average Water Quality Values

Landuse	Location Observation				
	1	2	3	4	5
Forest	14.3	14.31	14.33	14.44	15.08
Agriculture	28.2	32.54	42.63	45.61	50.7
Built-up Area	19.2	0.94	33	45.52	56.53
Shrubs	1.12	1.12	1.14	1.49	0.08
Rate Mean BOD	12.425	13.75	12.5	11.5	9
Rate Mean COD	32	39.5	48.5	49.5	55
Rate Mean DO	1.85	3.095	1.9	1.575	1.545

Desc: Solokan Jeruk (1); Sapan (2); Dayeuh Kolot (3); Jembatan Cilampeni (4); Nanjung (5).
Source: Research Results (2023)

Statistically by looking at the value of the coefficient of determination (R^2) shows a significant contribution value. Meanwhile, each parameter is presented as follows:

3.1.1 Landuse Culture and BOD

Biological oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume under aerobic conditions when decomposing organic matter [10]. BOD is also one of the methods to assess water quality by calculating the oxygen demand for the decomposition of organic matter [11]. The increase in BOD concentration will affect the life of biota in the waters [12].

As explained, the applicability of the parameter is used in identifying the BOD level in the main river flow to the land use culture in the upstream Citarum area. The correlation graph obtained between the two variables is visualized in Figure 2. The specific correlation analysis equation is presented in Table 2.

Table 2. Correlation between Landuse Culture (X) and BOD Level Value (Y)

Equation	Independent Variable (X)	Correlation Equation to BOD Level Value (Y)	R^2	Contribution (%)	Other factors (%)
1	Forest	y = -4.9903x + 84.155	R^2 = 0.8784	87.84	12.16
2	Agriculture	y = -0.1487x + 17.774	R^2 = 0.61	61.00	39.00
3	Built-up Area	y = -0.0735x + 14.118	R^2 = 0.8193	81.93	18.07
4	Scrub	y = 2.5015x + 9.3585	R^2 = 0.5631	56.31	43.69

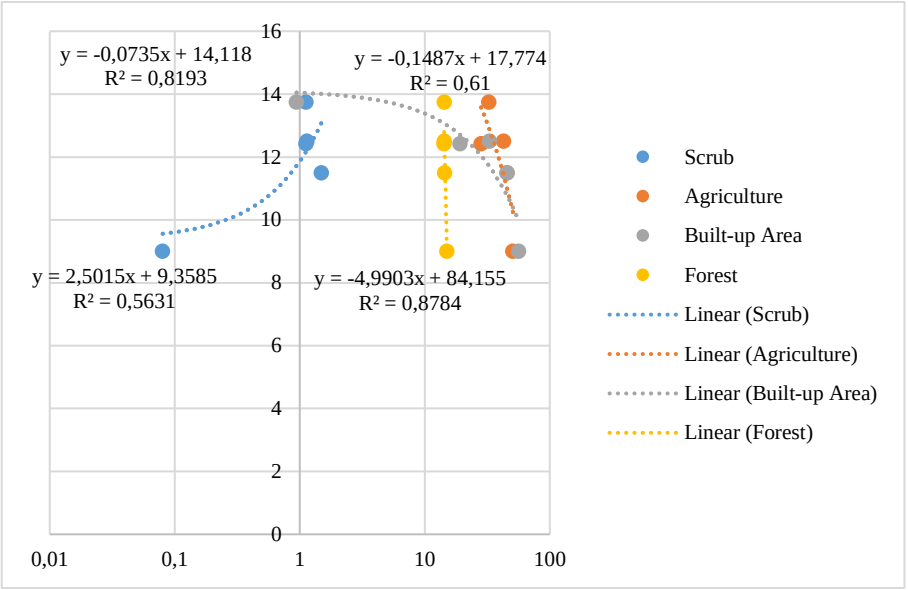

Fig 2. Graph of Land Use Correlation to BOD Level Value

The result of the correlation analysis equation shows that the largest BOD level in the land use zoning in this case study is forest area (87.84%), which is presumed to originate from animal waste in the upstream area of the Citarum. In addition, the built-up area zoning also has a large contribution to the BOD level in the river, reaching 81.93%.

Based on the results of previous studies, BOD comes from the use of the river as a toilet [13], household waste disposal [13, 14, 15], industrial waste [15, 16, 17, 18], and livestock waste [19, 20, 21]. Some of these materials are sources of BOD fluctuations in the river.

3.1.2 Landuse Culture and COD

Chemical oxygen demand (COD) is the amount of matter measured by chemical methods that needs to be oxidized in water, especially organic contamination [10]. The COD content of the river stream represents the level of pollution in the water body due to organic matter [22]. Several activities such as disposal of detergent residues, disposal of laundry residue water, disposal of food waste and garbage disposal can increase COD in streams. Domestic waste from households is directly discharged into river bodies, resulting in a decrease in water quality. Organic materials such as human and animal feces contribute to the pollution load from domestic waste [23]. An increase in COD concentration will actually affect the life of biota in the waters [23].

As explained, the applicability of these parameters is used in identifying the COD level in the main river flow to the land use culture in the upstream Citarum area. The correlation

graph obtained between the two variables is visualized in Figure 3. The specific correlation analysis equation is presented in Table 3.

Tabel 3. Korelasi Landuse Culture (X) and Nilai COD (Y)

Equation	Independent Variable (X)	Correlation Equation to COD Level Value (Y)	R^2	Contribution (%)	Other factors (%)
1	Forest	y = 19.286x - 234.59	R^2 = 0.4986	49.86	50.14
2	Agriculture	y = 0.9658x + 6.3309	R^2 = 0.9779	97.79	2.21
3	Built-up Area	y = 0.3385x + 34.393	R^2 = 0.6597	65.97	34.03
4	Scrub	y = -7.6957x + 52.519	R^2 = 0.2025	20.25	79.75

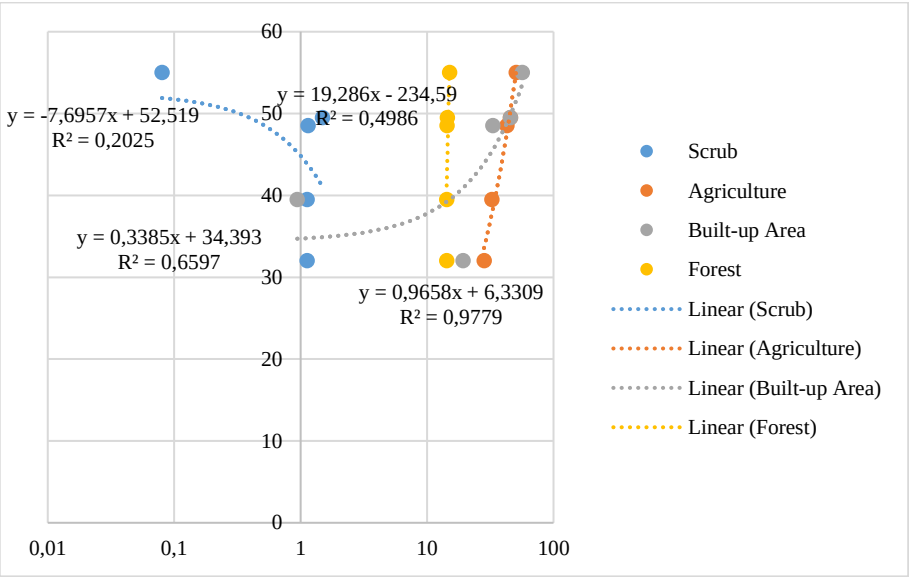

Fig 3. Graph of Land Use Correlation to COD Level Value

Based on the results of the correlation analysis equation, it shows that the COD level in the agricultural land use zoning is the largest contribution to the fluctuation of COD content in the river flow, reaching 97.79%. It is temporarily assumed that agricultural activities for fertilizer use also affect the COD content of the upstream Citarum River. In addition, built-up areas such as settlements also contribute 65.97%. As in previous studies, COD content comes from household wastewater [24] and waste from industrial areas [13, 25, 26, 27].

3.1.3 Landuse Culture and DO

Dissolved oxygen (DO) is an important water quality parameter that affects the living conditions of all aquatic organisms that require oxygen. DO levels in water bodies can be affected by anthropogenic activities and natural events in the catchment area [10]. Some experts add that DO is one of the most important variables affecting water quality. Low DO concentrations can directly affect water quality and disrupt healthy ecological balance [28; 29]. Pollutants such as sewage, soil, agricultural runoff, and other organic pollutants can reduce the DO saturation of water [30]. In addition, the DO content of a stream is a barometer of the ecological health of a stream and is the most important parameter for protecting fish [31, 32].

Basically, based on the applicable guidelines, water with DO <5% is in an area with very severe pollution; DO between 5 and 10% is at a severe level of pollution; DO in the range of 10-70% indicates a moderate level of pollution, while DO above 70% indicates mild pollution conditions or no pollution at all. Heavy pollution load due to untreated sewage and industrial effluents is the main cause of the decrease in DO concentration [33, 11].

As explained, the applicability of these parameters is used in identifying the COD level in the main river flow to the land use culture in the upstream Citarum area. The correlation graph obtained between the two variables is visualized in Figure 4. The specific correlation analysis equation is presented in Table 4.

Table 4. Correlation of Landuse Culture (X) and DO Value (Y)

Equation	Independent Variable (X)	Correlation Equation to DO Level Value (Y)	R^2	Contribution (%)	Other factors (%)
1	Forest	y = -0.8989x + 15.02	R^2 = 0.222	22.20	77.80
2	Agriculture	y = -0.04x + 3.5912	R^2 = 0.344	34.40	65.60
3	Built-up Area	y = -0.0257x + 2.7916	R^2 = 0.7809	78.09	21.91
4	Scrub	y = 0.2727x + 1.723	R^2 = 0.0521	5.21	94.79

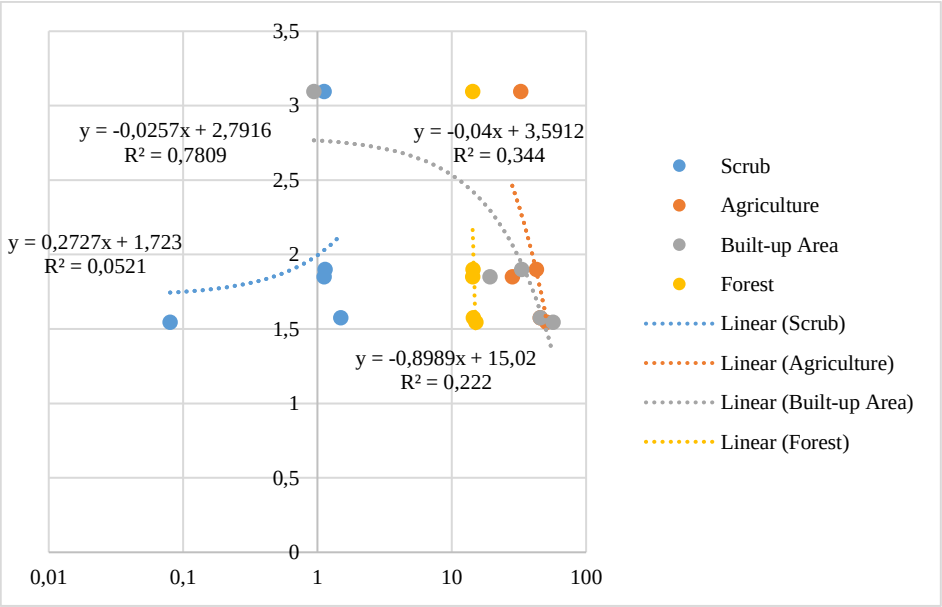

Fig 4. Graph of Land Use Correlation to DO Level Values

Based on the results of the correlation analysis equation, the DO level in the built-up area land use zoning contributes 78.09% to the DO content in the upstream Citarum River. In previous studies, DO was sourced from untreated residential and industrial wastewater [34, 27]. In addition, agricultural zoning also contributes 34.40% to the presence of DO content in the water body. This can come from agricultural activities that use pesticide fertilizers.

3.2 The Handling Strategy and Quality of Water

The Citarum River is one of the strategic rivers in West Java Province, so it requires strategic measures based on the land use culture identified in the river corridor. The land use culture

includes several zonations including (1) Forest land zoning; (2) Agricultural land zoning; (3) Built-up area land zoning; and (4) Shrub land zoning. These zonations are key to the development of a strategy to address the sources of water pollution in the upper Citarum river basin. It is hoped that the construction of the treatment matrix can serve as a policy reference for the local government to assist the Citarum harum program and realize a sustainable, beautiful and radiant Citarum. There are several handling strategies that have been implemented (Table 5).

Table 5. River Pollution Management Strategy

Quality of Water	Handling Strategies
BOD (Biological oxygen demand)	1) Develop a river greening environmental movement group. 2) Development of community-based forest area management. 3) The community is expected to carry out advanced processing of livestock and agricultural waste. 4) Socialization of agricultural institutions is needed to provide innovations and alternatives in the use of fertilizers. 5) Development of proper sanitation for river corridor communities to avoid open defecation. 6) Community empowerment in doing the 3Rs (Reuse, Reduce, and Recycle) for domestic waste management strategies. 7) Synergy program with educational institutions regarding river corridor community education programs in improving ecoliteracy. 8) Making infiltration wells (biopori) for the surrounding community. 9) Socialization of the development of the ecoliteracy level of the river corridor community on an ongoing basis. 10) Implementation of cultural festivals related to river conservation. 11) Availability of waste bank units along the river corridor. 12) The public is encouraged not to dispose of household waste in the river through public service announcements. 13) Guidance and supervision of AMDAL for industrial areas to create green industry. 14) Further management of industrial waste disposal needs to be done. 15) Massive supervision needs to be carried out by the local government in the disposal of industrial waste. 16) Development of Wastewater Treatment Plant (WWTP) units in MSME industries. 17) Land management in critical land conservation continues to be pursued in an effort to reduce the resulting disasters such as floods and landslides. 18) No expansion of shrub land in river corridors. 19) Conducting river renaturalization to turn shrub areas into greening areas (reforestation).
COD (Chemical oxygen demand)	1) Conservation of critical land in the upstream Citarum area based on Micro Watershed. 2) Developing river greening environmental movement groups. 3) Development of community-based forest area management 4) The community is expected to carry out advanced processing of livestock and agricultural waste. 5) Socialization of agricultural institutions is needed to provide innovations and alternatives in the use of fertilizers. 6) Guidance and supervision of AMDAL for industrial areas to create green industry. 7) Further management of industrial waste disposal needs to be done.

	8) Massive supervision needs to be carried out by the local government in the disposal of industrial waste. 9) Development of Wastewater Treatment Plant (WWTP) units in MSME industries. 10) Land management in critical land conservation continues to be pursued in an effort to reduce the resulting disasters such as floods and landslides. 11) No expansion of shrub land in the river corridor. 12) Conducting river renaturalization to turn shrub areas into greening areas (reforestation).
DO (Dissolved oxygen)	1) Conservation of critical land in the upstream Citarum area based on Micro Watershed. 2) Developing river greening environmental movement groups. 3) Development of community-based forest area management. 4) The community is expected to carry out advanced processing of livestock and agricultural waste. 5) Socialization of agricultural institutions is needed to provide innovations and alternatives in the use of fertilizers. 6) Development of hazardous and toxic waste management units (B3). 7) Land management in critical land conservation continues to be pursued as an effort to reduce the resulting disasters such as floods and landslides. 8) No expansion of shrub land in river corridors. 9) Conducting river renaturalization to turn shrubbery areas into greening areas (reforestation).

4 Conclusion

The trend of river pollution issues is currently in the spotlight, considering that in 2013 the World Bank released data that the Citarum river is one of the dirtiest rivers in the world. Responding to this data, efforts continue to be made by the West Java provincial government, especially in tackling water pollution in the Citarum river. In this study, the intention is to model empirically by correlating land use culture with water quality focusing on organic chemistry (BOD, COD, DO). The results of this modeling as a source of support in developing strategic handling strategies in suppressing water pollution that occurs.

The results of empirical relationship modeling identified (1) BOD value with forest zoning was identified (87.84%), a temporary presumption of this finding can be sourced from animal waste in the upstream Citarum area. In addition, in built-up area zoning (81.93%), the figure could be sourced from toilets, household waste, industrial waste, and livestock waste; (2) COD value in agricultural land zoning contributes the most (97.79%) and built-up area (65.97%); DO value in built-up area land zoning contributes the most (78.09%).

This correlation analysis mapping underlies the constructivistic strategies for handling potential water pollution in the future, such as the development of river greening environmental movement groups, conservation of critical land in the upstream Citarum area based on Micro Watershed, advanced management of livestock and agricultural waste and others. As stated in the previous discussion, it is hoped that the research data can become a relevant reference for the government, academics, practitioners, environmentalists, and other researchers to take action as a reference for implementing activities that go green to achieve the fragrant Citarum program in the future.

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