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Water Quality Evaluation System to Assess the Brantas River Water

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Abstract Water quality degradation in the Brantas' river will increase from the year to year due to increasing of the wastewater production as well as forests and land degradations resulting from population growth, urbanization and economic and industrial developments. Assessment of river water pollution is usually conducted by a comparison between the effective water quality and the standards regulated by law. The formulation of the water quality standards are commonly considered either the water utilization purposes or the water quality degradation. The water quality evaluation system (WQES) is used to evaluate the available water condition that distinguishes into two categories i.e., the water quality index (WQI) and water quality aptitude (WQA). The assessment of the Brantas river water quality from five selected stations was found that the WQI situates in the very bad class and the WQA ranges from most suitable quality for agriculture uses to unsuitable for leisure and sport activities.

Keywords Water quality evaluation system · Water quality index · Water quality aptitude

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1 Introduction

Water resources management entails the development of appropriate quantities of water with an adequate quality. The deterioration of water quality reduces the usability of the resources for down-stream stakeholders. By 2001, the government of Indonesia under the water resources sector reformation framework has been issued the Government Regulation no. 82 on Water Quality Management and Pollution Control (PP no. 8/2001). This PP no. 8/2001 is the national guideline to refer in managing of water quality especially for the water managers and operators who working with the related institutions at the national, provincial and river basin levels. To handle the problems of river pollution are currently based on the national policy. The objectives setting up in the policy are not suitable to perfectly implement at the specific local conditions spreading differ for different rivers entire the country. Although the regulation consists of the role sharing amongst the related institutions as well as the technical arrangements including the classification of the national water quality criteria, the operational guidelines in implementing of the regulation to the specific characteristics of a river basin is still not correctly envisaged. Conducting an adaptive guideline to the local condition is necessary (Fulazzaky 2005). For instance, salinity tolerance of macro-invertebrate communities varies in Eastern Australia hence water quality guidelines should be developed at a local or regional scale (Dunlop et al. 2008), and the nutrient pollution effects of moderate eutrophication on Runde river in Zimbabwe need to be addressed by appropriate agricultural and environmental policies that relate to water pollution and land use (Tafangenyasha and Dube 2008).

Several approaches have been introduced to assess the status of water quality in the stream (Shastry et al. 1972; Aston et al. 1974; Lizcano et al. 1974; Nunes et al. 2003; Tsegaye et al. 2006; Meeroff et al. 2008). The water quality index (WQI) has been considered as one criterion for surface water classifications, based on the use of standard parameters for water characterization (Bordalo et al. 2006; Sánchez et al. 2006). As the approaches and policy objectives differ for different countries it prefers to develop the specific tool of each authority. For example, Malaysian Department of Environment to consider six parameters i.e., DO, BOD, COD, SS, NH_4^+, and pH has been promoted as the tool to define the status of surface water quality (Shuhaimi-Othman et al. 2007; Sari and Wan Omar 2008). The use of different tools can lead to inconsistencies for different places even though the kind and quantity of pollutants are similar. The earlier tools promoted are not responsible to assess all the water quality parameters in checking the water quality status comprehensively. For instance, a major contribution of phosphorus affects the degradation of stream and lake water quality through algal blooming and associated eutrophication (Hoorman et al. 2008) since the lack of phosphorus in analysis data can lead an inaccurate explanation of water quality status. Hence, the most suitable tool is necessary to analyze all the measured parameters to translate the data to the information of actual condition in the river.

Water quality evaluation system (WQES) has been developed to response the market demands on the classes of water quality in accordance with the condition of water in the stream and the classes of water suitability in accordance with the available water quality in the river (Oudin et al. 1999). This method considers that the temporal and spatial variations need to be adjusted. The WQES serves to assess the status of water quality in the stream and to identify what the level of water is suitable to provide for different uses and its ecosystem. This tool is a comprehensive model approach in evaluating of water quality. The previous study showed that a modelling approach can be used to estimate the impacts of water quality management programs in river basins (Holvoet et al. 2007). The models are possible to recommendations for different levels of treatment derived in order to improve the water quality (Muhammetoglu et al. 2005). To apply the aggregation method of samples, the WQES is capable to define the status of water quality and also the aptitude of water for different uses by grouping the different indices. Each indication has the threshold to characterize the level of impact affecting water quality. Interpretation of these indices is to represent the quality or aptitude of water by selecting the worst quality of parameter(s) in the alteration to represent the quality of alteration and then the worst alteration(s) to represent the actual water quality for the monitored station. To define the status of water quality is possible to consider all the parameters measured while the aptitude of water is analyzed to focus on the related parameters for its purpose. The outcomes of water quality assessment via the WQES are appealed to consider the formulation of the water quality standards and the priority of measures to each region in the country or anywhere, based on specific local conditions. A systematical analysis of water quality data scientifically introduces to translate the data to the actual explanations may be envisaged as the decision support system (DSS). The accurate information obtained helps the decision makers in preparing the locally adaptive policies and guidelines to water quality assessment and management and warns the water users to wisely allocate their water right.

The objectives of this study are (1) to assess the status of water quality in the Brantas' river and to recommend the priority of measures that needs to be envisaged by the local authority, and (2) to identify the suitability of water providing the water uses and its ecosystem for warning in performing of water to different uses and to advice the related local governments in improving of water quality.

2 WQES to Assess the River Water

Application of WQES is a part of water quality monitoring process that aims to convert the data to information. Since the data of water quality may be interpreted individually in accordance with the experiences and knowledge of personal expert, the interpretation of water quality data becomes doubt and uncertain information (Fulazzaky 2005). An interactive fuzzy multi-objective linear programming (IFMOLP) model have been introduced to simulate the allocation of waste load efficiencies with satisfactory results which indicate usefulness of the model in managing more complex river basins along with better flexible policies of water management (Singh et al. 2007). The WQES is envisaged to possess the operational procedure standard (OPS) for generating the data to information. The information produced from the WQES are grouped into two categories i.e., water quality status and water suitability for different uses and its ecosystem, see Fig. 1.

The first important of WQES is used to asses the status of water degradation in the stream to support the local authority in managing of water quality. This status is commonly referred as WQI. In spite of difference in the concept, the WQI was

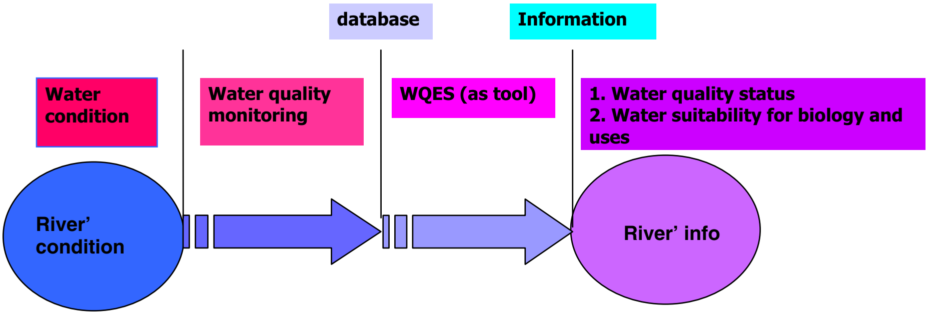

Fig. 1 Link of river water quality condition to river water quality information

used to assess spatial and long temporal variations in water quality over the last 25 years in the Río Lerma basin, Mexico (Sedeño-Díaz and López-López 2007). The second important is to identify the suitability of water, refer as water quality aptitude (WQA), for differ uses and its ecosystem. This information is useful to the water users to perform their water allocation in accordance with the suitable purposes such agriculture, fishery, livestock watering, etc., and to the local authority to handle the priority of programs in accordance with the urgent requirement.

2.1 WQES Steps in Assessment of River Water

The following steps are carried out to assess river water quality using the WQES that are:

- grouping the parameters of water quality into 15 alterations that classify in accordance with their similar nature and its impact on environment (see Table 1);
- defining the thresholds of each parameter into five classes with respective colours of blue, green, yellow, orange, and red to express the excellent quality of unpolluted water, good water quality, moderate water quality, bad water quality, and unusable water quality of very polluted water respectively (Oudin et al. 1999);
- formulating the classes and WQI in accordance with degradation of water quality that ranges from 0 to 20 for index-5, greater than 20 to 40 for index-4, greater than 40 to 60 for index-3, greater than 60 to 80 for index-2, and greater than 80 to 100 for index-1 (see Fig. 2) and formulating the classes and aptitude of water for different uses and its ecosystem in accordance with the level of suitability or WQA that ranges from the most suitable to unsuitable water (see Fig. 3; Oudin et al. 1999; Fulazzaky 2008);
- assessing the value of each parameter and put it into the respective classes of WQI for water quality status or WQA for water suitability to different uses and its ecosystem;
- verifying the worst quality of parameters and choice it to represent the quality of related alteration;
- identifying the worst quality of alterations and choice it to represent the WQI for water quality status or the WQA for water suitability to different uses and its ecosystem (aquatic biota).

Table 1 Water quality parameters in accordance with their alteration

Number	Alteration	Parameters
1	Oxidized organic matter	O_2, %O_2, COD, $KMnO_4$, BOD, DOC, NKJ, $NH_4{}^+$
2	Nitrogen matter	$NH_4{}^+$, NKJ, $NO_2{}^-$
3	Nitrates	$NO_3{}^-$
4	Phosphorus matter	$PO_4{}^{3+}$, P-total
5	Suspended particles	SS, Turbidity, Transparency
6	Colour	Colour
7	Temperature	Temperature
8	Mineralization	Conductivity, Salinity, Hardness, Cl^-, $SO_4{}^{2-}$, Ca^{2+}, Mg^{2+}, K^+, Na^+, TAC, Hardness
9	Acidification	pH, Dissolved Al
10	Microorganisms	Total coliforms, Feacal coliforms, Feacal streptococci
11	Phytoplankton	ΔO_2, ΔpH, %O_2, and pH, Chlorophyl a + pheopigments, Algae
12	Mineral micro-pollutants in raw water	As, Hg, Cd, Cr-total, Pb, Zn, Cu, Ni, Se, Ba, CN
13	Metals in bryophytes	As, Hg, Cd, Cr-total, Pb, Zn, Cu, Ni
14	Pesticides in raw water	List of pesticides (see Oudin et al. 1999)
15	Organic micro-pollutants non-pesticides in raw water	List of organic micro-pollutants non-pesticides (see Oudin et al. 1999)

Sources: Oudin et al. 1999

To assess the classes of WQI and WQA, 151 parameters of water quality are divided into 15 alterations (see Table 1). The alteration classifies the parameters in accordance with their similar nature and its impact on environment. The 15 alterations are (1) oxidized organic matter, (2) nitrogen matter, (3) nitrate, (4) phosphorous matter, (5) suspended particles, (6) colour, (7) temperature, (8) mineralization, (9) acidification, (10) microorganisms, (11) phytoplankton, (12) mineral micro-pollutants in raw water, (13) metals in bryophytes, (14) pesticides in raw water, (15) organic micro-pollutants non-pesticides in raw water (Oudin et al. 1999). An example of oxidized organic matter to assess the WQI is presented in Table 2 and an example of suspended particles to assess the WQA is presented in Table 3 (Oudin et al. 1999).

Index (range)	Class	Quality
1 (> 80 - 100)	blue	excellent
2 (> 60 - 80)	green	good
3 (> 40 - 60)	yellow	moderate
4 (> 20 - 40)	orange	bad
5 (0 - 20)	red	very bad

Fig. 2 Classification of water quality index*. *Source: Oudin et al. 1999 modified by Fulazzaky 2008

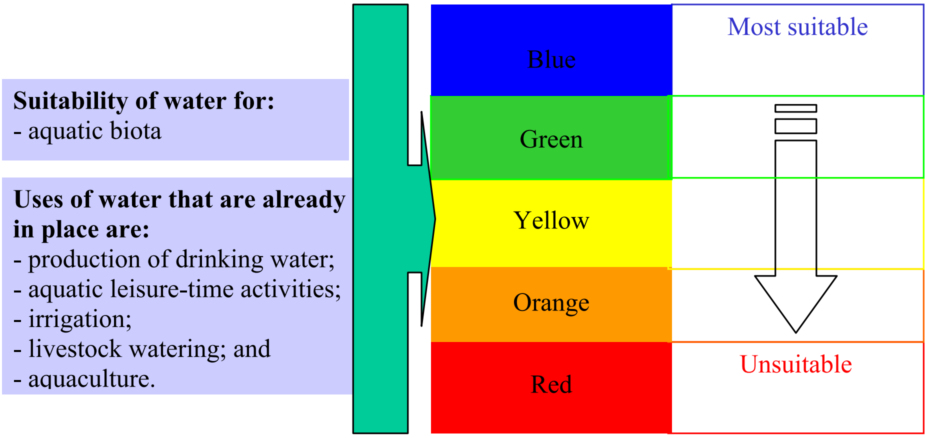

Fig. 3 Classification of water suitability for uses and aquatic biota*. *Source: Oudin et al. 1999 modified by Fulazzaky 2008

The assignment of WQI is fixed five consecutive classes that express in the index-1, index-2, index-3, index-4, and index-5 respectively. The index-1 means the class of excellent quality of unpolluted stream water that represents in blue colour, the index-2 the class of good quality of stream water that represents in green, the index-3 the class of moderate quality of stream water that represents in yellow, the index-4 the class of bad quality of stream water that represents in orange, and the index-5 is the class of unusable quality of very polluted water that represents in red (Oudin et al. 1999; Fulazzaky 2005). An example of WQI classes for the oxidized organic matter alteration shows in Table 2 (Oudin et al. 1999).

The assignment of WQA is fixed to assess the suitability of water for different targets of water uses and the impact of pollution on degradation of biodiversity. The biological potential function shows the suitability of water for aquatic life, when hydrological and morphological conditions of the habitat are good. The pollutants in the stream water such metals and organic matters affects on the biodiversity and sediment quality. For instance, despite high metal concentrations associated

Table 2 Oxidized organic matter alteration to assess the WQI

Parameter	Unit	Thresholds for WQI classification				
		Index-1	Index-2	Index-3	Index-4	Index-5
DO	mg/L O_2	8	6	4	3	< 3
Sat. O_2	% O_2	90	70	50	30	< 30
BOD	mg/L O_2	3	6	10	25	> 25
COD	mg/L O_2	20	30	40	80	> 80
PV	mg/L O_2	3	5	8	10	> 10
DOC	mg/L C	5	7	10	12	> 12
NH_4^+	mg/L NH_4	0.5	1.5	2.8	4	> 4
NTK	mg/L N	1	2	4	6	> 6

Source: Oudin et al. 1999

COD chemical oxygen demands, *BOD* biochemical oxygen demands, *DOC* dissolved organic carbons, $NH_4{}^+$ ammonium, *NTK* nitrogen total Kjeldahl with roots, the major part of the metals in the marsh soil is still associated with the sediment as the overall biomass of roots is small compared to the sediment (Teuchies et al. 2008). Five suitability classes have been defined. They indicate a gradual impoverishment of the biological structure, including the disappearance of the taxa most sensitive to pollution (Oudin et al. 1999).

Defining the suitability classes for the production of drinking water depends on (1) the related regulations which are held as priorities for defining the blue/green class thresholds associated with suitability for consumption and orange/red class thresholds associated with unsuitability for the production of drinking water and (2) the opinion of the producers and of the suppliers in defining intermediary thresholds for simple and complex treatments of raw water. The definition of suitability classes has been grouped in five classes. An example of WQA classes for the suspended particles alteration shows in Table 3 (Oudin et al. 1999).

The use of leisure and aquatic sport is mainly applied in bathing areas and the legislation thresholds which principally related relate to the turbidity of the water and the occurrence of microorganisms. Three suitability classes for recreation and aquatic sport have been defined (Oudin et al. 1999).

The main factors to classify the suitability of water for irrigation are: ground texture, irrigated crop, frequency and duration of irrigation. Crops have been divided into four sensitivity groups, ranging from very sensitive plants to very hardy plants. The crops taken into account in these groups are liable to differ from one parameter to another, meaning that the composition of each group is also variable. For instance, the arsenic content in soil and plants is influenced by the degree of arsenic amount in irrigated water (Dahal et al. 2008). It is equally necessary to take into account the type of soils. These have been divided into two groups which overlap i.e., (1) all soils including the most sensitive, and (2) neutral or alkaline soils, which are the most resistant. Combinations of soil/plant groups have been limited to sensitive-very sensitive plants/all soils and to resistant-very resistant plants/alkaline or neutral soils. Five suitability classes for irrigation use have been defined (Oudin et al. 1999).

Livestock watering use is the suitability of water to allow the watering of breeding animals. These can be classified according to three age classes and sensitivity, i.e., (1) young animals as chicken, pigs, calves, which are growing fast and are very sensitive to all pollutants, (2) animals of mature age which have a slow growth and are less vulnerable, and (3) animals for reproduction, they have strict needs during the gestation and milking period. In the case of livestock watering, water has to be useable immediately by the breeder. If the water is not useable, the breeder will then turn to the water supply. Three suitability classes for livestock watering use have been selected (Oudin et al. 1999).

Aquaculture use mainly shows the water suitability to be used in fish breeding. Water is the main factor of production in intensive fish breeding, particularly in

Table 3 Suspended particles alteration to assess the WQA to product drinking water

Parameter	Unit	Thresholds for WQA classification				
		Blue	Green	Yellow	Orange	Red
SS	mg/L	5	50	2,000	5,000	>5,000
Turbidity	NTU	2	35	1,500	3,750	>3,750
Transparency	M	2	1	0.1	0.05	<0.05

Source: Oudin et al. 1999

salmon breeding. Water carries oxygen, eliminates wastes and conditions production performances by its physico-chemical variability. Three suitability classes for aquaculture have been selected (Oudin et al. 1999).

2.2 Method to Define the WQI and WQA

As the starting point of WQES practice is to compile a number of the results as the raw data monitored during one period of data collecting. Due to temporal and spatial variations of the raw data affect on the inconvenient explanation. The screening of raw data are necessary to have the valid data from multiplies measurement (see Fig. 4). All the rational samples are selected to assess the level of pollutants affecting water using the aggregation method. The objective of this aggregation method of

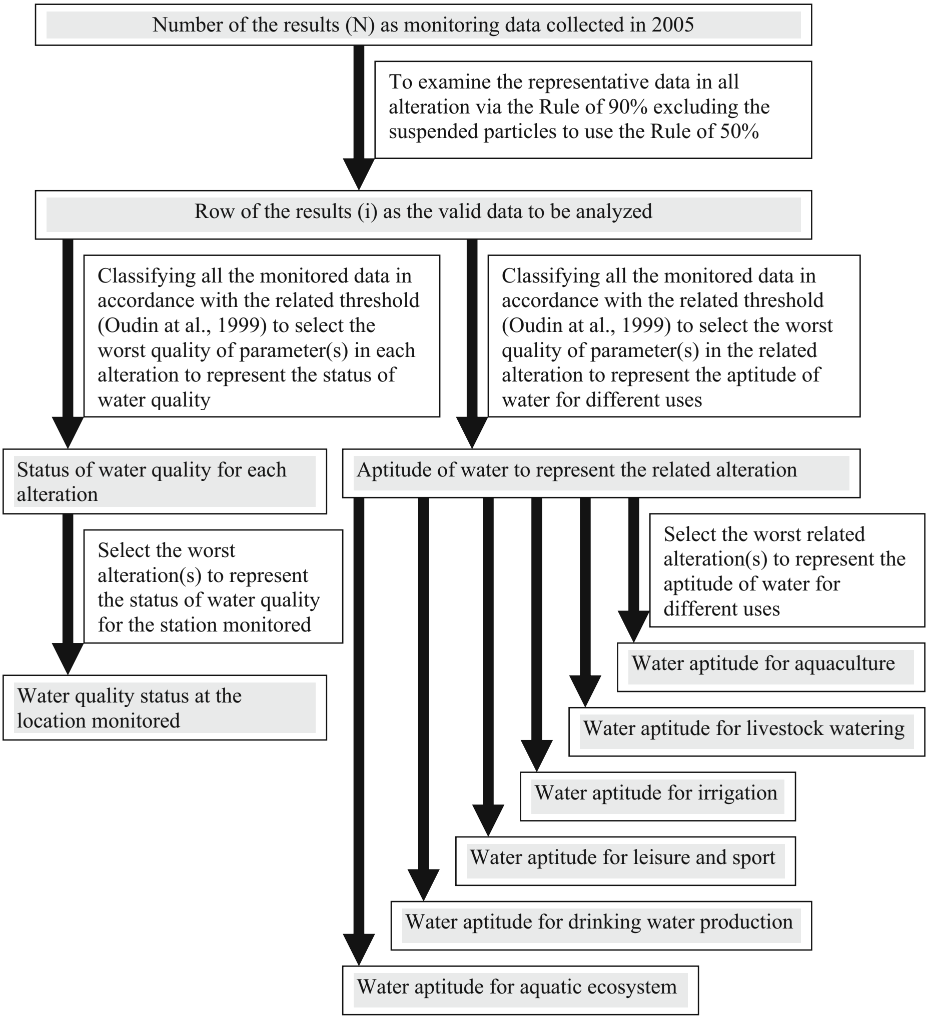

Fig. 4 Flow chart of aggregation method to asses the river water

samples is to produce the assessment of suitability or quality in acute conditions but to avoid taking into account exceptional situations. Therefore, one is looking to keep back the samples giving the worst suitability or the worst quality, on condition that it has been observed in at least 10% of the samples. It is the so-called “90% rule”. This rule enables holding only 90% of the observed results over one period of time, these results being for each alteration describes the suitability classes, quality classes and quality indexes. The rule of 90% is valid for all the alterations except for the alteration of suspended particles.

Every parameter has thresholds for each class of WQI and WQA categories (Oudin et al. 1999). To evaluate the data of water quality should be to start the selection of the worst quality of the parameters in each alteration to represent the WQI or WQA of related alteration. To follow after identifying of the worst quality of alteration is enacted as the class of WQI or WQA of the river water at the monitoring location (see Fig. 4). Due to the comprehensive analysis are to include all the measured parameters, this method can be promoted as the OPS at anyplace to support the local or national policies and objectives of water quality management. Since the water quality status and the suitability of water to different uses are understood, the recommendations to improve water quality and to warn the water users may be proposed.

3 Using WQES to Assess Water Quality of the Brantas’ River

This study examines 1,136 results that were monitored in 2005 from five selected stations along the Brantas river (see Fig. 5). This is the results compiling from the annual report produced by the Jasa Tirta 1 Public Corporation (PJT1). Since it was not measured all the parameters (see Tables 1, 4 and 5), the 11 alterations can be analyzed to roughly assess the Brantas water quality. To convert the data to information, more parameters are to consider more detail explanations are obtained. To assess the classes of WQI and WQA of river water in the Brantas’ river using the WQES is to carry out after screening of the data via the Rule of 90% that is

$$F = (i - 0.5)/N \text{ or } i = 0.9\ N + 0.5 \quad (1)$$

where,

i is row of the results;
N is total number of results;
F 0.9 is percentage or 90% of acceptable data to evaluate.

For example, in keeping the rule of 90% or $F = 0.9$, the total number of results (N) for COD at the station 0160 Kedung Pedaringan is 9 to collect from nine times of monitoring in 2005. This gives $i = 8.6$, rounded to 9, and it should be to keep all the COD results. To confirm the WQI = 4 for oxidized organic matter is due to the worst quality of seven monitored parameters of this alteration is the COD values which situate in the threshold of index-4. Because the worst WQI alterations of suspended particles and mineral micro-pollutants that were monitored at the same station are situating in the threshold of index-5, this informs that the stream water for this location has the WQI = 5 (see Table 4).

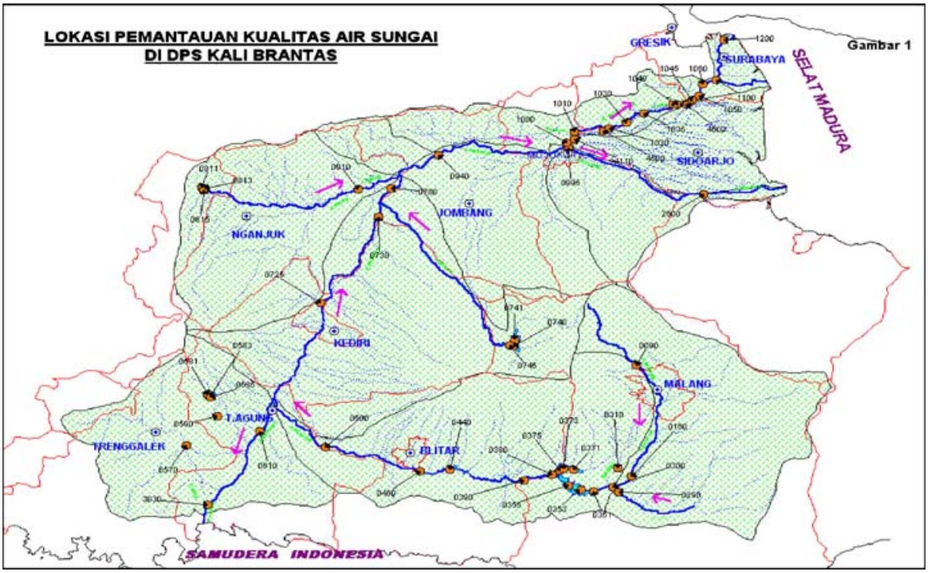

Fig. 5 Water quality monitoring stations along the Brantas river

To assess the alteration of suspended particles, the withheld rule is the 50% percentage, to avoid qualifying water after rainfall events which no exceptional characteristics and with a frequency superior to 10%. The formula is then

$$i = 0.5\ N + 0.5. \quad (2)$$

These rules need to implement due to results of water quality monitoring along the Brantas river are numerous. Since 1987, the PJT1 as the institution in charge to monitor water quality of Brantas' river has been selected to monitor 51 locations as shown in Fig. 5.

The number of parameters monitoring as shown in Tables 4 and 5 are respective examined of 28, 22, 25, 26, and 25 parameters to evaluate the water quality status and of 26, 20, 23, 24 and 23 parameters to evaluate the water aptitude for different uses from five locations i.e., 0160 Kedung Pedaringan, 0940 Ploso, 1020 Perning, 1100 Ngagel, 2600 Porong respectively along the Brantas river. Because of lack of data monitoring for 4 alterations i.e., colour, microorganisms, pesticides in raw water, and organic micro-pollutant non-pesticides in raw water as shown in Table 4, are no include to evaluate in this study.

3.1 WQI of Certain Locations in the Brantas' River

Based on the data of water quality monitoring in 2005, Table 4 shows that all the locations selected have been polluted highly by suspended particles and mineral micro-pollutants. High concentration of suspended solids was found in the river due to the increase of erosion especially in the upstream area of the river basin. This

Table 4 WQI to assess the status of water quality

Alteration	Number of monitoring and WQI									
	0160		0940		1020		1100		2600	
	i	WQI	*i*	WQI	*i*	WQI	*i*	WQI	*i*	WQI
Oxidized organic matter	9	4	8	4	9	4	10	5	9	5
Nitrogen matter	9	3	8	3	9	5	10	3	9	3
Nitrate	9	3	7	2	9	2	10	2	8	2
Phosphorous matter	9	4	8	5	9	4	10	5	9	5
Suspended particles	9	5	3	5	9	5	10	5	9	5
Colour										
Temperature	9	1	8	1	9	1	10	1	9	1
Mineralization	9	1	8	1	9	1	10	1	9	2
Acidification	9	1	8	1	9	1	10	1	9	1
Microorganisms										
Phytoplankton	9	2	8	3	9	3	10	2	9	4
Mineral micro-pollutants in raw water	9	5	1	5	7	5	8	5	7	5
Metals in bryophytes	9	4	5	1	7	3	10	1	7	3
Pesticides in raw water										
Organic micro-pollutants non-pesticides in raw water										
WQI of each location	5		5		5		5		5	
Number of parameters analysis	28		22		25		26		25	

Remarks of location: 0160 Kedung Pedaringan; 0940 Ploso; 1020 Perning; 1100 Ngagel; 2600 Porong.
Source: Fulazzaky 2005

is the impact of cumulative land and forests degradation because of since 1998 the practices of legal and illegal logging as well as conversion of land use have been increased progressively. A high concentration of copper and mercury in the stream may be affected either from the industrial wastewater, or mountainous eruption. The previous study indicated that the potential acute toxicity in sediment of Wuli River in China may be primarily due to Hg contamination (Zheng et al. 2008). Mercury deposited to aquatic ecosystems becomes less available for uptake by biota over time (Orihel et al. 2008). The contribution of mercury in the stream is not constant and can vary greatly over time in response to watershed inputs (Balogh et al. 2008). Any risks associated with high metal concentrations are, however, likely to be greatest in habitats such as arable and horticultural, improved grassland and built up areas where soil metal concentrations are more frequently elevated. Metal distributions and risks explained by balance of sources and soil property effects on fate (Spurgeon et al. 2008). Regarding the impact of metals on environment as mentioned in the previous studies this study suggests that the future detail researches are necessary to identify the sources of pollution and the impact on the ecosystem in the Brantas' river.

High pollutant of phosphorus matter was found in three of five locations. Organic pollutant tends to increase in the down stream area of the Brantas' river. Nitrogen matter was found highly in Perning where concentration of industries located in this area. This evaluation concludes that the WQI of all the selected location, as judging index-5, includes the very bad class. Evidently, to improve the water quality status in the Brantas' river the study recommends the priority of improvement of suspended particles and mineral micro-pollutants. This translates to focus firstly in charge to handle the problems of forests and land degradations and the pollutant loading from industrial wastewaters. To follow after the improvement of river water quality to reduce the pollutant loads coming from domestic wastewater.

3.2 WQA of Certain Locations in the Brantas' River

3.2.1 Suitability of Water for Aquatic Ecosystem

The excessive pollutants in the stream water will face the problems of biodiversity degradation. The previous study supports the need for incorporating functional measures in evaluations of stream ecological integrity (Castela et al. 2008). The effects on zooplankton were caused by changes in habitat structure due to the strong decline of macrophytes. The slow degradation of metazachlor combined with the absence of recovery in both chlorophytes and macrophytes is likely to cause long-lasting effects on aquatic ecosystems (Mohr et al. 2008). In this study, Table 5 shows that two of five stations monitoring of water quality located in the down stream of the Brantas' river are unusable to conduct the sustainability of aquatic ecosystem, judging the WQA class is red. This translates water capability of considerably reducing the number of sensitive taxa or eliminating them, with a very low diversity. The rests of three locations indicating of the orange class are the capability of considerably reducing the number of sensitive taxa, with reduced diversity (Oudin et al. 1999).

3.2.2 Suitability of Water for Drinking Water Production

Although the water supply treatment plant in Ngagel installing by Surabaya city's authority still operate until now, the quality of raw water used to produce drinking water is not recommended, judging the WQA class is red (see Table 5). Utilization of Brantas river water from the upstream area of Ploso station as judging the WQA

Table 5 WQA to assess the suitability of water for different uses and its ecosystem

Type of water uses	Number of monitoring and WQA									
	0160		0940		1020		1100		2600	
	i	WQA	*i*	WQA	*i*	WQA	*i*	WQA	*i*	WQA
Biological potential function	9	Orange	8	Orange	9	Orange	10	Red	9	Red
Drinking water production use	9	Orange	8	Orange	9	Orange	10	Red	9	Red
Leisure and aquatic sports use	9	Red	8	Red	9	Red	10	Red	9	Red
Irrigation use	9	Blue	8	Blue	9	Blue	10	Blue	9	Blue
Livestock watering use	9	Yellow	8	Yellow	9	Yellow	10	Yellow	9	Yellow
Aquaculture use	9	Yellow	8	Yellow	9	Yellow	10	Red	9	Red
Number of parameters analysis	26		20		23		24		23	

Remarks of location: 0160 Kedung Pedaringan; 0940 Ploso; 1020 Perning; 1100 Ngagel; 2600 Porong class is orange is possible to produce drinking water. This study recommends perform the advance technologies in producing of drinking water.

3.2.3 Suitability of Water for Leisure and Sport Activities

Although the whole of 51 stations monitoring along the Brantas' river are not presented completely in this study, reckoning from five selected locations indicate that the stream water is unusable to leisure and sport activities, judging the parameters' row to assess the WQA is situated in red class (see Table 5).

3.2.4 Suitability of Water for Irrigation

The results of data analysis recording in Table 5 show that all the WQA of five selected stations is situated in blue class. This translates that the Brantas' river is still most suitable to provide water for irrigation purposes especially paddy fields as a major part of water uses in the region. But unfortunately, the overflow of irrigated water is usually to drain back into the river. The runoff from paddy field as verified in the Ile de Camargue, France, carries important loads of dissolved pesticides to the wetlands including river (Comoretto et al. 2008).

3.2.5 Suitability of Water for Livestock Watering

Utilization of Brantas river water to provide the livestock watering of mature animals that are less vulnerable such bovine and ovine, needs to control strictly the quality of water used, judging the row of water quality parameters to assess the WQA includes in yellow class (see Table 5).

3.2.6 Suitability of Water for Aquaculture

Despite of water in the down stream area is unsuitable for direct use in aquaculture indicating the WQA is situated in red class, the results of water quality assessment in Table 5 show that stream water in the Brantas' river from the upper Ploso station is suitable for all adult fishes which are not very sensitive to pollution.

4 Conclusion

The WQES was used to assess the status of water quality and the suitability of water for different uses and its ecosystem in the Brantas' river. The level of water quality degradation expressed generally in term of WQI was examined to conclude very bad quality. This study recommends to the local authority to envisage the certain priority in order to handle the problems of pollution i.e., (1) launching the program of rehabilitation of forests and land especially in the upstream area of the Brantas river basin and (2) implementing the measures to reduce the pollutant loads from industrial and domestic wastewaters consecutively.

The suitability of water was examined through WQA assessment to warn the utilization of water to the leisure and sport activities, to recommend the advance technologies in treating of water from the upper Ploso station and no utilize the water in the down stream area to produce drinking water, and to control strictly the quality of water using for livestock watering and aquaculture purposes. The quality of water in the Brantas' river will affect on degradation of biodiversity especially in the down stream area. Participatory surface water management is emphasized in order to achieve a holistic and sustainable water management decision making process (Hartmann et al. 2006). The local governments and related institutions including all other stakeholders should be to involve for improving the Brantas river water quality comprehensively.

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