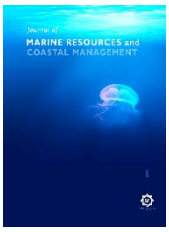
JOURNAL OF MARINE RESOURCES AND COASTAL MANAGEMENT
INDONESIAN JOURNAL OF MARINE LIFE AND UTILIZATION

e-ISSN: 2722-0966
Vol. 3 Issue 2



Economic valuation approach to calculating pollution loads in Kenjeran coastal area, Surabaya, East Java, Indonesia

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ABSTRACT

Environmental pollution is not a new problem in the Kenjeran, Surabaya coastal area. There are numerous studies show that these waters have been polluted. However, there is no specific study on the economic valuation of environmental impacts due to pollution that occurs in the area. The purpose of this study was to estimate the costs incurred from pollution that occurred in the Kenjeran coastal area. The estimation of the cost of pollution is done by calculating the decrease in fishery productivity and the tourism sector, and the increase in health and water treatment costs. Data collection techniques were carried out through secondary data collection, interviews, questionnaires, field surveys, and focused group discussions. The calculation results show that the costs incurred from pollution that occur in the coastal area of Kenjeran are IDR 452,724,903,588 include (1) a decrease in fishery productivity in the form of lost fisherman income of IDR 28,728,000,000; (2) a decrease in the tourism sector by IDR 27,728,112,300; (3) the increase in health costs includes the cost of carcinogenic risk of IDR 363,626,479,099 and gastroenteritis of IDR 32,552,893,425; and (4) an increase in the cost of water treatment by IDR 89,418,763. This effort is needed to remind policy makers of the importance of paying attention to the impacts arising from an activity on the environment and society as well as to show that environmental aspects are an important potential for long-term sustainable development activities and not as an obstacle to development.

Keywords: pollution costs, economic valuation, willingness to pay, travel cost method, health costs, lost income

INTRODUCTION

In general, environmental damage that threatens the sustainability of coastal and marine resources in the Kenjeran coastal area is mainly caused by pollution originating from the disposal of industrial, household and rubbish waste, in addition to physical degradation of habitat and over-exploitation of natural resources. Specifically, sources of water pollution in the Kenjeran coastal area come from industrial waste, sewage, urban stormwater, shipping activities, agriculture and aquaculture.

There have been many research results and scientific studies which show that these waters are polluted. One of the studies regarding pollution in the Kenjeran coastal area shows that the heavy metal content in Kenjeran waters has far exceeded the sea water quality standards stipulated in the Decree of the Minister of Environment No. 51 of 2004 [1]. From the results of this research, the highest content of heavy metals lead (Pb) and copper (Cu) in Kenjeran waters is 13.5933 mg/Kg and 30.7187 mg/Kg respectively, while the sea water quality standards for both heavy metals are only 0.008 mg/L.

The research results of [2] stated that there was a significant correlation between respondents who consumed contaminated fish in Kenjeran waters and Hg levels in their hair. Respondents who consumed an average of 99.11 grams of fish/day had Hg levels in their hair of 0.511 ppb. The results of the research also indicate indications of disease symptoms that occur in those who consume fish from Kenjeran waters, including kidney disease, dizziness, tumors, bleeding gums and visual disturbances. In addition, several areas, such as Kenjeran District, are classified as areas with high population density (201-400 people/ha). This will affect the health level of the population in the area, both directly and indirectly, because the increase in health status is related to population size.

However, there has been no specific research or study regarding the economic valuation of the environmental impact due to pollution that occurs in the Kenjeran coastal area. Economic valuation of environmental impacts is the process of quantifying and assigning a monetary value to environmental impacts after previously carrying out an identification process or stage. This economic assessment of environmental impacts is important considering that the Kenjeran coastal area is one of the strategic areas which according to the Regional Spatial Planning Plan (*Rencana Tata Ruang Wilayah*/RTRW) of the City of Surabaya is in Development Unit 3. According to the RTRW of the City of Surabaya, this area will be developed according to its function as a residential, trade and tourism, services and conservation.

Economic valuation of environmental impacts is needed as an effort to show that environmental aspects are potentially important for the long term in sustainable development activities and are not an obstacle to development. Therefore, efforts to quantify environmental

value need to be made to remind policy makers of the importance of paying attention to the impacts arising from an activity on the environment. Thus, the aim of this research is to estimate the costs resulting from pollution that occurs in the Kenjeran coastal area. The Kenjeran coastal area in this study is specifically limited to Kenjeran and Bulak District.

METHODS

The conceptual model for estimating the cost of pollution in the Kenjeran coastal and marine areas in the framework of total economic value (TEV) in this research is shown in Figure-1. TEV is a combination of use value (UV) and non-use value (NUV). Use value consists of direct use value (DUV), which in this research is the commercial value of the fisheries and aquaculture sector as well as coastal tourism and recreational benefits; indirect use value (IUV) refers to benefits related to the function of marine ecosystems and marine biological resources without market value; and option value (OV) which relates to value for future use. Heritage value (bequest value, BV) and existence value (EV) are non-use values.

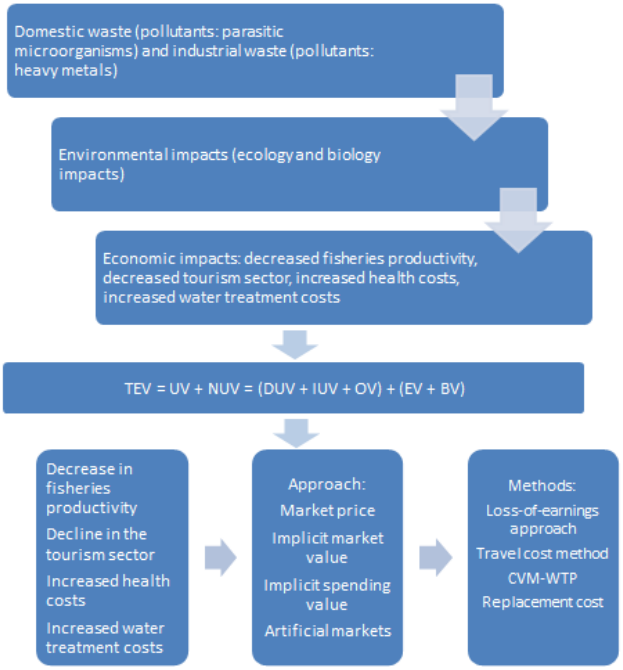

Figure-1. Conceptual model for estimating the costs of marine pollution in the Kenjeran coastal area in the framework of total economic value

Before carrying out a quantitative assessment of the impacts due to pollution in the coastal and marine areas of Kenjeran, first identify the impacts that may arise due to pollution in the area through a literature search. Searching for relevant literature at this stage specifically takes the form of collecting supporting data related to risks that may arise due to domestic and industrial waste pollution in the Kenjeran coastal area, including: concentration of pollutants, risk of exposure to pollutants, number of tourists, number of residents, fishermen's income, and the level of fisheries productivity.

Sources of data used are primary and secondary data. Data and information in this research are obtained in the following techniques: a) Interview, by conducting questions and answers or structured interviews with respondents regarding fishermen's income and the community's willingness to pay, as well as supporting data in the application of the contingent valuation method (CVM) and travel cost method (TCM); b) Questionnaire, collecting data by making a list of questions first and then distributing the questionnaire to the people who are the samples in this research using purposive random sampling; c) Field survey; and d) Focused discussion.

Decrease in Fisheries Productivity

The decline in fisheries productivity in this study was approached by estimating fishermen's lost income. This is based on pollution of coastal and marine waters which has the potential to result in a decrease in marine catches, thereby also affecting the decline in fishermen's income. Estimation of lost fishermen's income was carried out by multiplying fishermen's income by the number of fishermen in the research locus.

Decline in the Tourism Sector

In this research, so that the calculation is preventive, the decline in the tourism sector is approximated by the loss of economic value from the tourism sector on the Kenjeran coast. The economic value of the tourism sector on the Kenjeran coast is then calculated using TCM.

To estimate the economic value of the tourism sector, two variables are used, i.e. the independent and the dependent variable. An independent variable is a variable that influences or causes changes or is caused by related variables. In this study the independent variables consisted of age (x_1), education (x_2), income per month (x_3), length of visit (x_4), alternative options (x_5), and frequency of visits (x_6). Meanwhile, the dependent variable is a variable that is influenced or caused by the existence of an independent variable. In this study the dependent variable is travel costs.

Furthermore, travel costs (y) are influenced by the independent variable x (age, education, income per month, length of visit, alternative options and frequency of visits). After the data related to the variables x and y are tabulated again according to the parameters contained in the linear equation as shown in Equation [1-3], then regression techniques can be used to estimate each coefficient of the function.

$$TCS = CS_i \times V_i \quad [1]$$
$$CS_i = -V_i/\beta_i \quad [2]$$
$$lnV_i = \beta_0 + \beta_1 TC \quad [3]$$

where TCS is total consumer surplus as a proxy for the value of an area, CS_i is consumer surplus per individual, V_i is individual visit rate to i, and TC is total travel costs,.

Increased Health Costs

The calculation of health costs in this study is the accumulated cost of the risk of carcinogens and gastroenteritis in tourists due to the use of waters that have been contaminated with heavy metals and pathogenic microorganisms. Carcinogen risk costs refer to [3]. The risk level for gastroenteritis was calculated using Equation [4] constructed by Cabelli et al. (1982) in [4]. The risk

level for gastroenteritis is then multiplied by the number of visitors or tourists who have the potential to suffer from gastroenteritis, to obtain the number of gastroenteritis sufferers due to the use of waters that have been contaminated with pathogenic microorganisms. Furthermore, the cost of gastroenteritis risk is obtained based on the number of gastroenteritis sufferers which is calculated by the average costs incurred by a gastroenteritis sufferer [5].

$$y = 12.2(log_{10}x) + 0.2 \quad [4]$$

where *x* is an average concentration of enterococci/100 ml and *y* is risk of gastroenteritis/1000 people.

Increased Water Treatment Costs

The increase in water treatment costs due to pollution of coastal and marine areas is approximated by the costs of managing waste before it enters marine waters. Data analysis used to estimate waste management costs in this research was carried out using the reference of [6].

RESULTS AND DISCUSSION

Environmental Data: Heavy Metal Pollution

As a densely populated residential area, the increase in industrial development has increased the potential for heavy metal pollution in the Kenjeran coastal area. This heavy metal pollution will not only affect the quality of the coastal and marine environment but will also impact the sustainability of marine biota in the region. Heavy metal pollution in Kenjeran coastal waters has been widely studied. The levels of copper metal (Cu (II)) in Kenjeran waters are in the range of 0.065-0.096 mg/L. This level exceeds the seawater quality standards set for Cu parameters, 0.05 mg/L [7].

Previously, the results of analysis carried out by [8] showed that the concentration of several types of metals in Kenjeran waters such as zinc (Zn), mercury (Hg), lead (Pb), nickel (Ni), cadmium (Cd) and copper (Cu) are generally still below the established quality standards. The metal levels were respectively 0.003 mg/L; 0.001 mg/L; 0.0036 mg/L; 0.0339 mg/L, 0.001 mg/L and 0.015 mg/L. The maximum threshold value or quality standard for metal pollutants zinc (Zn), mercury (Hg), lead (Pb), nickel (Ni), cadmium (Cd), and copper (Cu) is 0.095 mg/L respectively; 0.002 mg/L; 0.005 mg/L; 0.075 mg/L; 0.002 mg/L and 0.05 mg/L based on Decree of the Minister of Environment of the Republic of Indonesia No. 51 of 2004 concerning Sea Water Quality Standards for marine tourism.

Furthermore, research by [1] showed high concentrations of lead (Pb) and copper (Cu) in sediments in Kenjeran waters. The metal concentrations of Pb and Cu in these sediments reached 13.6 mg/kg and 30.7 mg/kg respectively at observation stations located close to land. This shows that there is a distribution of Pb and Cu metals originating from human activities on land towards coastal and marine areas.

The level of heavy metal pollution that occurs in Kenjeran waters, which is increasing from year to year, will have an impact not only on changes in the condition of marine water quality parameters such as oxygen content, degree of acidity (pH), temperature, dissolved nutrients and dissolved suspended solids, but it will also have an impact on microorganisms and marine biota [9-11].

The average levels of lead (Pb) in water, sediment and gastropods were 0.175 ppm, 1.646 ppm and 0.291 ppm respectively. Meanwhile, the quality standards for marine waters are stipulated in the Decree of the Minister of Environment No. 51 of 2004, namely the sea water quality standard for the heavy metal lead (Pb) content in waters is 0.005 ppm. This shows that the levels of lead (Pb) in Kenjeran waters have exceeded the specified seawater quality standards.

Environmental Data: Domestic Waste

Based on Minister of Environment Decree No. 112 of 2003 concerning Domestic Wastewater Quality Standards, domestic wastewater is wastewater originating from businesses and/or residential activities, restaurants, offices, commerce, industry, apartments and dormitories. Domestic waste, also known as household waste, consists of three important fractions, i.e. feces, urine, and has the potential to contain pathogenic microbes. Generally, domestic waste also contains organic materials such as Nitrogen (N) and Phosphorus (P).

In the Kenjeran coastal area, people generally dispose of domestic liquid waste through pipes, either leading to receiving water bodies or flowing directly into the ground. For the trade and industrial sectors in coastal areas, this domestic liquid waste flows directly into the sea. This causes the organic content and chemical compounds in domestic liquid waste to accumulate in estuary and sea areas. Several parameters that can be reviewed to determine the level of pollution of marine waters in the Kenjeran coastal area from domestic waste products include the degree of acidity (pH), total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrients such as ammonia and phosphate, and detergent surfactants. Tests for the quality of domestic wastewater, taken from septic tank pipes in one of the residential areas to represent the characteristics of domestic waste, in Tambak Wedi Village, Kenjeran District are shown in Table-1.

Table-1. Characteristics of domestic wastewater in Tambak Wedi Village, Kenjeran District, Surabaya [12]

Parameter	Concentration	Unit
pH	6,58	-
TSS	10,644	mg/L
COD	3,040	mg/L O_2
BOD	1,580	mg/L O_2
N (ammonium)	354,84	mg/L NH_3-N
P (phospat)	10,77	mg/L PO_4-P
Total coliform	27×10^5	MPN

Detergent waste is classified as domestic waste which can reduce the quality of water. This detergent waste needs to be processed or given treatment before being discharged into water bodies so that it does not pollute the environment and reduce water quality. In general, people do not process the waste they produce before throwing it into the water, including the people of Tambak Wedi, Kenjeran. People in Tambak Wedi Village tend to throw detergent waste directly into the water, which has an impact on decreasing the quality of Tambak

Wedi's water. The pollution load of detergent waste in Tambak Wedi Village, Kenjeran is shown in Table-2.

Table-2. Discharge and load of detergent wastewater pollution in Tambak Wedi Village, Kenjeran District, Surabaya City [13]

Number of washings for 1 month = 12 times	
Number of washings produced in 1 month = 219,612 kg of clothes	
Measured waste discharge = 35 m^3/day	
Actual liquid waste discharge = 420 m^3/ day	
Maximum liquid waste discharge = 3,513 m^3/ day	
Pollution Load	**BOD_5**
Monthly maximum	0.0016 mg/liter
Monthly actual	0.323 mg/liter
Daily maximum	0.0292 mg/liter
Daily actual	5.924 mg/liter

Furthermore, the parameters of coliform bacteria in Kenjeran coastal waters reached 1.6×10^5 jpt/100 ml. This value far exceeds the specified quality standard (1000 jpt/100 ml). The marine tourism sector uses sea waters for many activities or human activities such as swimming, canoeing, and so on. The relatively high presence of total coliforms has the potential to cause serious health problems for people who use these waters.

One gram of feces can contain one billion infective virus particles which can survive for several weeks at temperatures below 10°C [14]. These microorganisms are usually identified as coliform bacteria in water quality measurements. Specifically, coliform bacteria are a group of rod-shaped gram-negative bacteria that are aerobic or facultative anaerobic and do not form spores. Most coliform bacteria originate or live in the digestive tract of warm-blooded living creatures, such as humans and animals. Although not all coliform bacteria are dangerous to human and animal health, because coliform bacteria are present in the digestive tract and feces of living creatures, these bacteria associate with other pathogenic microorganisms that also live in the same habitat. This makes coliform bacteria one of the water quality parameters that indicate the presence of anthropogenic pollutant contamination in the form of human feces in a body of water.

Economic Data

There are a few literature regarding the economic assessment of the results of environmental damage due to pollution that occurs in the coastal and marine areas of Kenjeran. Research conducted by [3] analyzed waste processing costs and carcinogenic risk costs due to contamination with heavy metals cadmium (Cd) and mercury (Hg). It was stated that a significant cause of heavy metal pollution in Kenjeran waters was industrial waste discharge and resulted in fish living around the industrial waste disposal area being contaminated with heavy metal waste. People who consume this fish have the potential to be contaminated with heavy metals through the food chain process.

The analysis results show that the volume of industrial liquid waste in Surabaya containing Cd is estimated to reach 23,536,300 liters per day and the volume of waste containing Hg reaches 4,095,300 liters per day. The average risk of carcinogens for Kenjeran coastal communities due to Cd contamination is 8×10^4 with an average treatment cost of 6 billion rupiah. Meanwhile, the average risk due to Hg contamination is 4×10^4 with an average cost of 294 billion rupiah. Cd waste processing costs range between 0.78-109 billion rupiah and Hg waste processing costs 0.002-0.21 billion rupiah. Optimization results show that the optimum Cd and Hg concentrations in Kenjeran waters are 0.007 mg/1 and 0.009 m/1.

Estimation of Pollution Costs

Decrease in Fisheries Productivity

The Kenjeran coastal area of Surabaya, which is part of the eastern part of Surabaya, is one of the areas with a fairly high population of fishermen. Based on data from the [15], in 2018 there were 2,066 residents who worked as fishermen spread across 11 coastal sub-districts. This figure decreased from the previous 2,266 fishermen in 2017. On the other hand, in general fisheries productivity in Surabaya experienced fluctuations from year to year throughout 2015 to 2018 (Figure-2). In 2018, fishermen's catch reached 8,151.5 tonnes, which was obtained from sea catches.

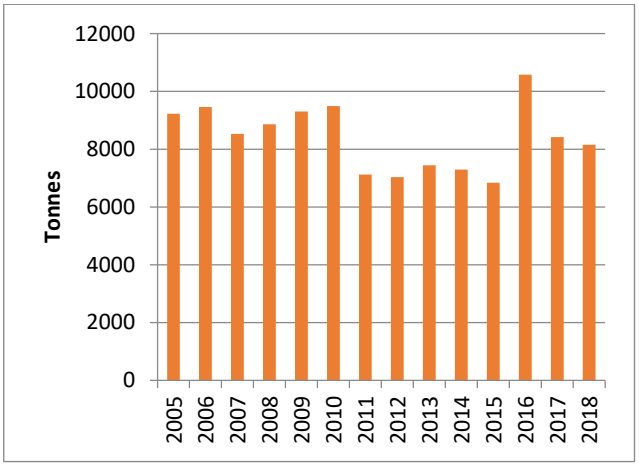

Figure-2. Marine fish production (tonnes) 2005-2018

The impact of pollution on fishery products is also supported by data from the Maritime Affairs and Fisheries Service which states that since 1999 Indonesian shellfish products have been prohibited from entering the European Union market because they are not harvested from waters declared as certified areas. This ban can be lifted if Indonesia can show data on the classification of waters as clean and well-monitored shellfish fishing zones. Several other Indonesian marine fishery products have also experienced rejection from the European Union market due to pollution. In 2006 to mid-2007, there were 17 cases of rejection due to contamination of mercury (Hg), 7 cases of contamination of cadmium (Cd) and 1 case of contamination of lead (Pb).

Based on data from the [15], the average monthly income of fishermen is IDR 916,666. Meanwhile, the results of the focused discussions conducted showed that the average monthly income of fishermen was in the range of IDR 1,500,000 (minimum) to IDR 4,500,000 (maximum), with an average amount of IDR 2,500,000 – IDR 3,000,000. With the number of fishermen in 2020 in Kenjeran District and Bulak District being 163 and 635 people respectively [16], the estimated amount of

fishermen's income lost due to pollution in the Kenjeran coastal area per year is amounting to IDR 28,728,000,000.

Decline in the Tourism Sector

The decline in the tourism sector can occur due to many things, one of which is pollution. For example, during the summer of 1987 – 1988, beach clean-up activities (debris wash-up) due to marine pollution in New York and New Jersey, United States required the closure of access to several beaches. The accumulated economic losses from this event were estimated at $379.1 - $1597.8 million ($1987) [17].

Analysis of the economic value of the Kenjeran Beach tourism sector show that the calculated F value = 2.507 with a significance level of 0.000 <0.05. In this way, the regression model can be used to predict variable *x* or in other words there is an influence of variable (*x*) on variable (y). Furthermore, the calculation results also show that variable *x* has an influence on variable *y* with an R square (R^2) of 18.11%.

Of all these parameters, what needs to be considered to assess the model coefficients is the coefficient value and P-value according to the significance level criteria <0.05. Of the six independent variables determined, the variable that shows a P-value with a significance of less than 0.05 is the alternative option variable with a value of 0.009. Thus, the alternative option is the variable that has the most influence on travel costs.

Based on the regression results, the linear equation function for the value of *y* or willingness to pay (WTP per individu) can be denoted as follows:

$$\ln y = 5.311 + 0.142\ (ln\ x_1) - (0.141(ln\ x_2) + 0.316(ln\ x_3) + 0.519(ln\ x_4) + 0.813(ln\ x_5) + 0.237(ln\ x_6)$$

ln y = 10.785

y = IDR 48,300/individu

From the regression equation, the WTP value obtained is IDR 48,300/individu. With a total of 574,081 visitors (2018 data from UPTD THP Kenjeran), the estimated economic value of the Kenjeran coastal tourism sector per year is IDR 27,728,112,300.

Increased Health Costs

The average risk cost of carcinogens for Kenjeran coastal communities refers to [3], as shown in Table-3. Furthermore, before determining the level of gastroenteritis risk, risk assessment activities need to be carried out. According to [3], risk assessment is the final stage of risk assessment, where at this stage the results of exposure and dose-response assessments are integrated to produce conclusions about the level of health risk in a particular condition or scenario. During the risk assessment process, information on the toxicity of a specific substance and the dose-response relationship are compared in terms of a measure of the level of contaminant exposure that also takes into account the level of production of the contaminant and the process by which the contaminant travels to the target (receptor). Gastroenteritis risk assessments have been carried out previously by researchers including identification of types of danger, dose-response assessment, exposure assessment, and risk assessment [18].

Table-3. Costs due to heavy metal Cd and Hg contamination in Kenjeran waters, Surabaya

	Cost of treatment (2003) [3]	Cost of treatment (2020)*
Level of risk of carcinogens due to contamination Cd: 8×10^4	IDR 6 billion	IDR 9,917,085,793.63
Level of risk of carcinogens due to contamination Hg: 4×10^4	IDR 294 billion	IDR 353,709,393,306.16

*assuming an average inflation rate of 3%

In this study, the concentration of pathogenic microorganisms with indicators of coliform bacteria in the waters ranged from 2.1×10^2 to 4.5×10^5. Slanetz et al. (1965) in [19] found that the ratio between the concentrations of coliforms and *Faecal streptococci* (also called enterococci in [20]) in sea waters is estimated to be 10:1. Furthermore, using Equation [4], the calculation results for the gastroenteritis risk value range between 0.028-0.069 (28 to 69 people exposed out of 1000 people).

The risk level for gastroenteritis is then multiplied by the number of visitors or tourists who have the potential to suffer from gastroenteritis, to obtain the number of gastroenteritis sufferers due to the use of waters that have been contaminated with pathogenic microorganisms. The number of visitors or tourists is then assumed to be 574,081 people (2018 data from UPTD THP Kenjeran). The calculation results show that the risk of gastroenteritis sufferers due to the use of water contaminated with pathogenic microorganisms is 39,612 people.

Furthermore, the cost of gastroenteritis risk is obtained based on the number of gastroenteritis sufferers which is calculated by the average costs incurred by a gastroenteritis sufferer. The estimated economic burden or average costs incurred per gastrointestinal disease amounted to 36.58 US dollars [5]. Another study stated that the estimated economic burden per gastrointestinal disease was 42.02 AU dollars [21].

In order to produce preventive calculations, an estimate of the economic burden per gastrointestinal disease of 36.58 US dollars was used from research by [5]. By using an average inflation rate of 3%, the economic burden per gastrointestinal disease used in this research calculation is 58.7 US dollars (1 USD = IDR 14,000). Thus, the results of further calculations show that the estimated cost of the risk of gastroenteritis per year due to the use of waters contaminated with pathogenic microorganisms is IDR 32,552,893,425.

Previously, research by [17] also showed the impact of consuming fish contaminated with toxic pollutants which resulted in large economic losses. In the case of the Hudson and New York Bight river estuaries, consumption of striped bass alone, which was contaminated with PCBs at high consumption (13.38 kg/year) resulted in economic losses reaching $33,690 million ($1,987).

Increased Water Treatment Costs

The increase in water treatment costs due to pollution of coastal and marine areas is approximated by the costs of managing waste before it enters marine waters. The locus of research in this sector is Kenjeran District, specifically Tambak Wedi Village. This is because the related environmental data supports further calculations.

The water quality in Tambak Wedi Village is in a very worrying condition because it has been polluted (see Table-2 and 3). Most of the activities along the river are densely populated housing and home industry. Waste in the form of gray and black water is directly thrown into the river without undergoing treatment first, thus causing water pollution in Tambak Wedi. Apart from liquid waste, there was also a lot of plastic waste found in the river that flows along Tambak Wedi Village.

Cost estimation in waste water management is carried out to find out how much it costs to manage waste water. The cost estimates for each wastewater treatment technology given in this study were carried out using the reference of [6] as shown in Table-4. This cost estimate becomes a reference in calculating the valuation of investment costs as well as operation and maintenance costs (operational & maintenance/O&M costs) of waste water processing with different technologies where each technology used has its own comparative advantage. This helps to choose the right and optimal alternative technology to be used in waste management planning in the Tambak Wedi area, Kenjeran.

Table-4. Estimated value of waste management costs

Technology	O & M Costs (IDR/p.e)*	Invesment costs (IDR/p.e)*
Pond system	29.359.531,44	49.105.034,54
Intermittent sand filter	15.935.057	55.785.325,99
Constructed wetlands	10.535.346	57.996.690,47
Trickling filter	79.951.048,77	94.940.620,53
Moving bed biofilm reactor	13.752.510,41	94.890.803,68
Rotating biological contractors	54.490.662,95	2.246.077,78
Membrane bioreactor	46.813.305,94	213.199.455,92
Sequencing batch reactor	62.212.926,59	2.406.498,58

*p.e: population equivalent

Based on the conditions of society and the environment in the Tambak Wedi area, Kenjeran, the waste water management technology that is more appropriate to apply is constructed wetlands technology. Constructed wetlands technology is a wastewater management technology that utilizes natural processes. This system consists of aquatic vegetation, substrate, water, microorganisms and utilizes complex processes involving physical, chemical and biological mechanisms to improve water quality or remove pollutants. Constructed wetlands technology is also relatively cheaper so it is more suitable when applied in the Tambak Wedi area, Kenjeran at a cost of IDR 10,535,346 and investment costs of IDR 57,996,690.

CONCLUSION

The costs resulting from pollution that occurs in the coastal area of Kenjeran, Surabaya are IDR. 452,724,903,588 includes (1) a decrease in fisheries productivity in the form of lost fishermen's income of IDR 28,728,000,000; (2) a decrease in the tourism sector of IDR 27,728,112,300; (3) increased health costs include carcinogen risk costs of IDR. 363,626,479,099 and gastroenteritis IDR 32,552,893,425; and (4) an increase in water treatment costs of IDR 89,418,763.

It is necessary to add measuring tools to be able to see the economic impact of pollution in the coastal area of Kenjeran, Surabaya, especially in relation to the level of tourist visits. This is because in the Kenjeran coastal area there are lots of visitors who flock to the beach which may not be recorded. In addition, it is necessary to calculate the impact of heavy metal pollution in the Kenjeran coastal area spesifically on the decline in the quality of intelligence quotients (IQ) of children under five, either directly by consuming marine products from polluted beaches or seas or indirectly, for example from parents who consume marine products from polluted beaches or seas during pregnancy.

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