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EMERGING TRENDS IN ECONOMIC DEVELOPMENT AND RIVER WATER QUALITY IN BANTEN PROVINCE, INDONESIA: ONE DECADE AFTER DECENTRALIZATION POLICY IMPLEMENTATION (2000-2010)

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Abstract: This study analyzes the economic growth of Banten Province and river water quality (as environmental indicator) one decade after decentralization. Descriptive and multivariate statistics were used in data analysis. The results showed that Banten Province has achieved well economic growth. Its GDP has contributed to approximately 14.75% of the national GDP. At the same time, the population growth has increased significantly with an annual rate of 2.78. Nine physicochemical elements in Ciujung River showed increasing trends, especially in the last five years. Some parameters even exceeded their ambient values. Among the heavy metals, seven elements exhibited intensifying concentrations. Out of seven, iron has exceeded its ambient level. The organic materials in Ciujung River were also very high, indicated by the level of KMnO4 and *Escherichia coli* concentration. The multivariate statistics revealed that, although some elements showed intensifying concentrations, seasonal variability still played an important role in the water quality changes.

Keywords: Autonomy policy; Multivariate statistics; River pollution; Sustainable development.

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INTRODUCTION

The decentralization (autonomy) policy has been implemented in Indonesia since 1999 (Seymour and Turner, 2002). Since then, eight new provinces have been established, including Banten Province, to add up a total number of 33 provinces. By this policy, each province has its own freedom to self-govern and manage their budget and development planning with less interference from the central government (Yonariza and Shivakoti, 2008). By 2011, this policy has resulted in the creation of new economic regions (Firman, 2011). For some countries, economic development is like a coin. It has two side effects; one side can create regional development that leads to human prosperity and the other side can create environmental quality degradation and land cover change (Abdullah and Nakagoshi, 2006; Hasse and Lathrop 2003; Stagl, 1999). The negative effects of regional development can actually be minimized by good management (Collin and Melloul, 2003; Chakrabarty, 2001), but in most cases especially in developing countries, this is what usually too complex to be implemented (Rakodi, 2001). Jakarta city and Ciliwung watershed is an example wherein economic development and environmental degradation, *i.e.* air and water pollution, show strong negative correlation (Suwandana et al., 2011; Colbran, 2009; Steinberg, 2007). In the frame of promoting sustainable development, an evaluation on water quality and environmental degradation has to be done parallel with the improvement of economic sectors. The negligence in doing such a work may create other cities like Jakarta, where the rehabilitation of river water quality has become too late. This study was focusing on the investigation of water quality in Ciujung River using descriptive statistic and multivariate analyses. The analysis on economic development of Banten Province was also discussed to see the impact of decentralization policy implementation in this province. So far, there was no such study has been done in Indonesia, which the result from this study would be useful for the improvement of the environmental management programs.

EXPERIMENTAL

Study area: Banten Province, located in the west part of Java Island, constitutes several big rivers including Ciujung River. Mount Halimun, lying at an elevation of 1850 m, is the originating point of Ciujung River and the water flow ends up in the Banten Bay. The river has approximately 63 km long and passes through many villages and one big city (Rangkasbitung). The river is an integration of some small rivers, including Ciberang, Cisimeut, Cilaki and Cibogor rivers. All of these rivers altogether shape up the Ciujung watershed which covers a hydrological area of approximately 1,915 km^2. Compared to Ciliwung watershed, where includes some urban cities (Jakarta, Bogor, Cibinong and Depok), Ciujung watershed is still considered as rural area. The upper most part of the watershed is still covered by a conserved natural forest and the area in downstream is mostly used for agriculture activities. However, the population increase and economic development have started stimulating the changes in land use and land cover throughout the watershed. Some new industries were established along the Ciujung River and several new residential places and real estates were constructed in some cities, such as Rangkasbitung, Pandeglang and Serang.

Economic data: Selected social economic data were obtained from the Statistical Office of Banten Province (BPS Banten). The analysis of each economic indicator was compared with the same indicator in the national level. The focus of the analysis was on the economic data after the implementation of decentralization policy (2000-2010).

Water quality data: Composite water quality measurement has been regularly carried out at nine stations of Ciujung River in monthly basis by the Water Resources Office of Banten Province since 1998. The determined stations have been considered to represent upstream, middle stream and downstream area of the river (Figure 1). At the each station, 41 water quality parameters were measured. However, only the data recorded from 2000–2010 were used in the analysis. Meanwhile, for the multivariate statistics analysis, only 25 water parameters recorded from 2005–2010 were analyzed, due to the continuity of the data.

Statistical analysis: Descriptive statistics were performed to describe the water quality condition in the study site and to see the trend of each water parameter during 10-year observation. We used the standard limits from the Indonesian Government Decree No. 82/2001 regarding water quality management and water pollution control. An intensive analysis was focused on the lower most station in the downstream area (station no. 9), because the station is believed to receive and accumulate pollutants from the entire upstream stations. The range, mean and standard deviation of water quality data of Ciujung River is presented in Table 1.

However, descriptive statistics cannot explain the relationship between water parameters, due to complexity of the data. Hence, multivariate statistics were applied to explore more about the data and to find if any meaningful unexplained information. Multivariate statistics are able to figure out beneficial information which may not be able to be overcome by simple statistics (Li et al., 2009; Zhao and Cui, 2009; Shrestha and Kazama, 2007). In water quality studies, multivariate statistical techniques, such as cluster analysis (CA), principal component analysis (PCA) and factor analysis (FA), help in the interpretation of the complex database and offer a reliable understanding of spatio-seasonal relationships and hydrochemistry processes (Shrestha and Kazama 2007; Simeonov et al., 2004). CA is a wide range of multivariate techniques for explanatory data analysis whose main purpose is to assemble variables into clusters based on similarities (or dissimilarities) with respect to some predetermined selection criteria (Zhao and Cui, 2009;

Shrestha and Kazama, 2007). The cluster characteristics are not known prior to the analysis, but may be apprehended from the results (Singh et al., 2004). PCA is designed to transform the original variables into new, uncorrelated variables (axes), called the principal components. FA is designed to reduce the contribution of less significant variables to simplify even more the data structure resulting from PCA by rotating the axis defined by PCA, according to well established rules. This process constructs new variables, so-called varifactors (VF) as the main outputs of FA. PC is a linear combination of the original observed water quality variables, whereas FA can include unobservable, hypothetical, latent variables (Helena et al., 2000; Vega et al., 1998).

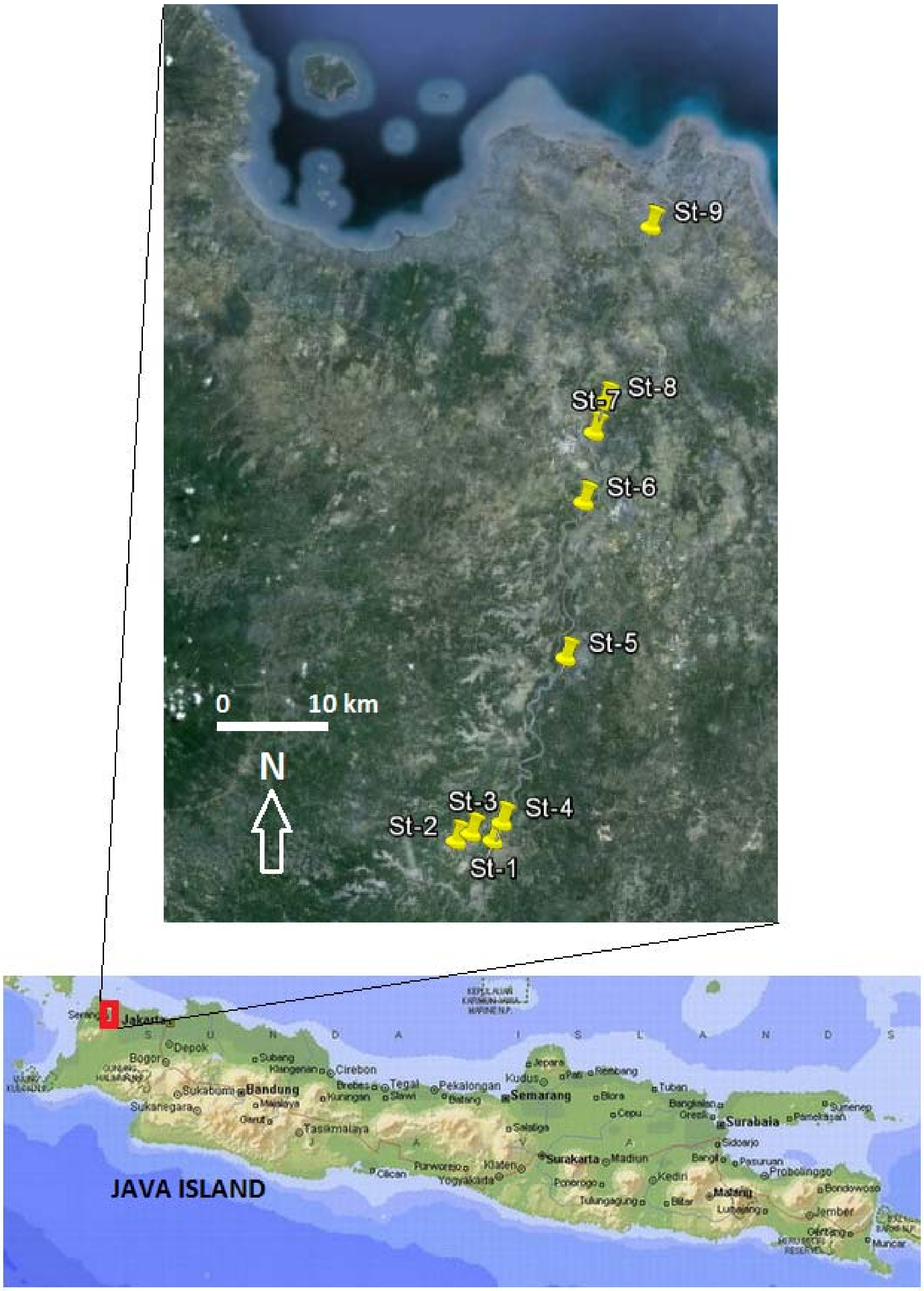


Figure 1. Water quality stations in Ciujung River, Banten Province.

Table 1. Minimum, maximum, mean and standard deviation of water quality parameters of Ciujung River compiled from 9 stations during 2000 – 2010.

Parameter	Unit	Min	Max	Mean	Standard deviation	Coefficient of variance
Temperature	ºC	21.600	34.800	28.455	1.551	5.451
Electrical conductivity	µS/cm	7.400	9,720.000	276.475	922.485	333.659
TDS	mg/l	23.00	5,340.000	135.947	446.186	328.206
Salinity	%	0.000	17.600	0.165	1.037	628.485
Turbidity	NTU	2.300	722.000	111.955	135.950	121.433
pH	-	5.520	9.410	6.761	0.448	6.626
Alkalinity	mg/l $CaCO_3$	2.100	282.800	41.049	34.712	84.562
DO	mg/l	0.421	7.449	4.101	1.031	25.140
COD	mg/l	0.909	646.800	37.082	35.511	95.763
BOD	mg/l	0.168	30.210	2.426	3.509	144.641
Chloride	mg/l	0.485	5,825.000	46.068	330.542	717.509
Nitrate	mg/l	0.021	18.547	2.724	2.082	76.432
Nitrite	mg/l	0.002	1.861	0.138	0.216	156.522
Sulfate	mg/l	0.024	250.478	12.143	24.383	200.799
Iron	mg/l	0.001	3.015	0.520	0.529	101.731
Copper	mg/l	0.001	0.095	0.009	0.007	77.778
Escherichia coli	Colony / 100 ml	400.000	460,000.000	40,629.966	44,058.798	108.439
TSS	mg/l	9.500	779.500	109.387	134.054	122.550
Total hardness	mg/l	6.000	1,920.000	74.751	107.633	143.989
Calcium	mg/l	0.600	262.000	18.034	22.057	122.308
Manganese	mg/l	0.061	155.520	8.436	11.359	134.649
KMnO4	mg/l	0.239	97.961	11.703	8.667	74.058
Chromium	mg/l	0.000	0.029	0.008	0.008	100.000
Lead	mg/l	0.000	0.081	0.007	0.007	100.000
Zinc	mg/l	0.002	0.968	0.038	0.146	384.211

In this study, we performed hierarchical CA technique in SPSS version 16.0 on the normalized (z-score) water quality data by the means of Ward's method using Euclidean distances as a measure of similarity. Data normalization is important to avoid miss classification, eliminate the influence of different units of measurements and render the data dimensionless (Zhao and Cui 2009; Liu et al., 2003). The CA was applied on the average monthly data of six years (2005–2010). An agglomerative dendrogram was produced, elucidating the seasonal similarities, where the distance between clusters was determined by the linkage distance, denoted by Dlink/Dmax. Meanwhile, PCA and FA were performed on the standardized full water quality dataset. Previously, Kaiser-Meyer-Olkin (KMO) and Barlett's test was performed on the datasets to examine the suitability (sphericity) of the data for PCA/FA. High value of KMO test (close to 1) normally indicates the adequacy of the data to be subjected for PCA/FA. The significance level which is 0 in this study (with KMO test value = 0.727) indicates the significant relationships among the variables. The PCA/FA was forced to extract five PCs with Eigenvalues > 1 summing almost 56% of the total variance in the datasets and the data was rotated using Varimax rotation method.

RESULTS AND DISCUSSION

Socio-economic Development

In the last ten years, the human population in Banten Province has increased from 8 million to 10.6 million with a provincial birth rate of 2.78 (Figure 2). The population growth has an implication on the increase of the electricity customers for almost 500% from 444,924 to more than 1.9 million customers. Consequently, the need of electricity consumption has also increased from 4.27 billion Kwh to 16.3 billion Kwh, in which a significant leap occurred in 2008. Besides household consumption, the number of new established factories has given much contribution to the need of electricity. In agriculture sector, Figure 3 illustrates the production increase in some important commodities, such as rice, chickens and ducks. For the last decade, the production increase has reached an average of 0.18 million ton•year-1, 2.82 million ton•year-1, 0.71 million ton•year-1, 0.35 million ton•year-1 and 0.11 million ton•year-1, corresponding to paddy, chicken broilers, chicken broilers (native species), chicken egg layers, and ducks. Overall, the regional development in Banten Province has shown a good performance (Figure 4). The value added of industry (VAI) of Banten Province has also increased from USD 3.18 billion in 2001 to USD 9.34 billion in 2010. The VAI, also referred to gross domestic products (GDP)-by-industry, has contributed to more than 50% of the province's total GDP, which has increased from USD 5.73 billion to USD 16.22 billion during the last decade (all figures are estimated at the rate of USD 1 = Rp 9,158). In turns, the provincial GDP has contributed to approximately 14.75% of the total national budget in 2010. At the end, the prosperity of Banten people can be observed from their expenditure per capita which increased from USD 66.19 in 2001 to USD 68.56 in 2010. With these achievements, Banten Province is considered to be one of prospective provinces in Indonesia in the last decade.

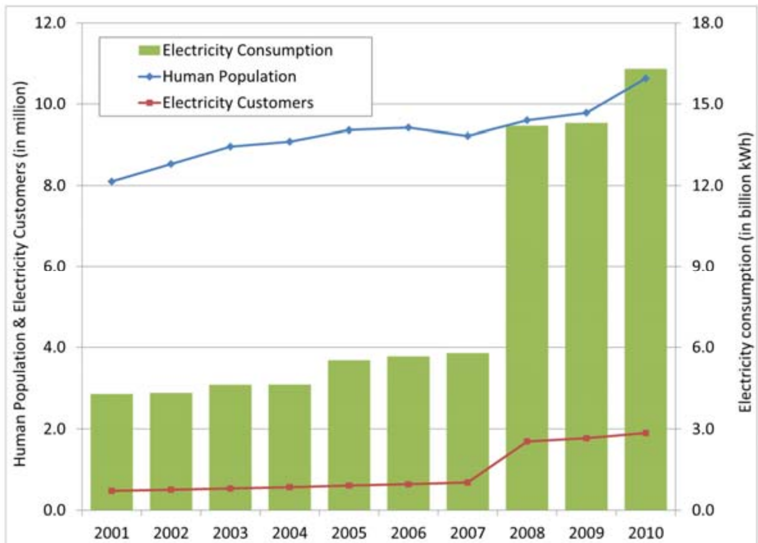


Figure 2.Trends of human population, electricity customers, electricity consumption in Banten Province during the period of 2001 – 2010.

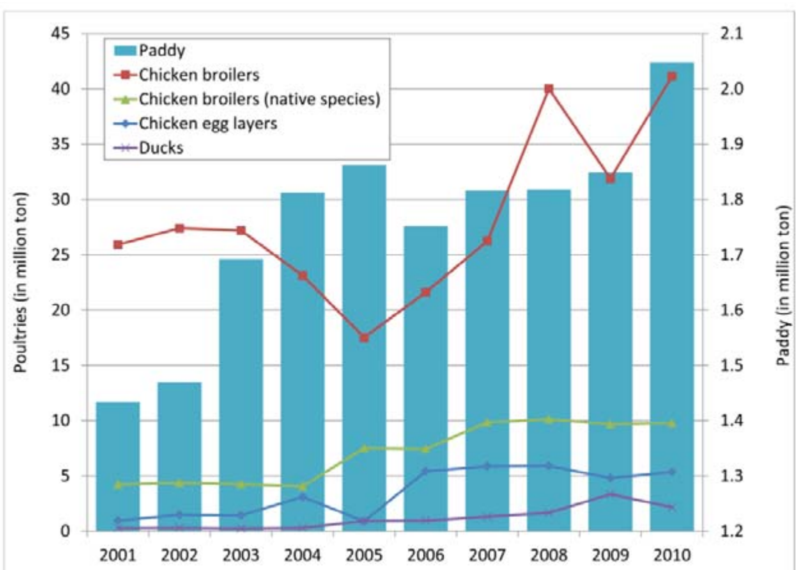


Figure 3.Some agriculture commodities in Banten Province during the period of 2001 – 2010.

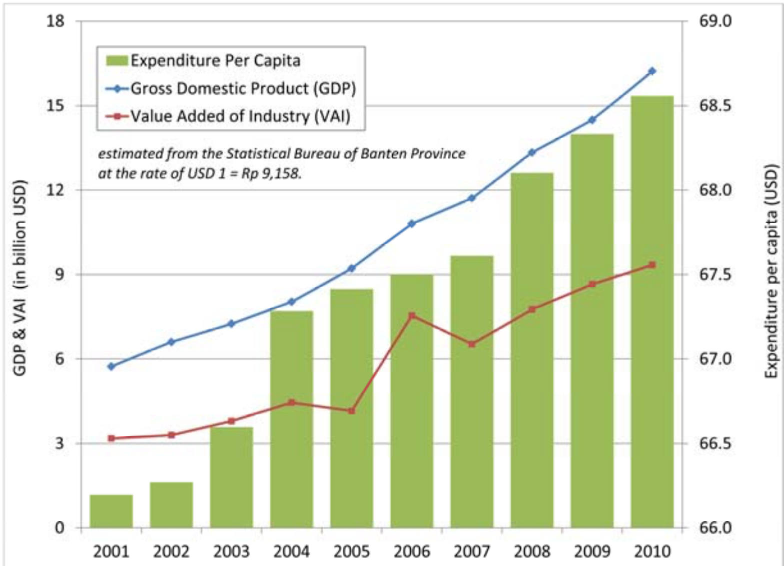


Figure 4.Some macroeconomic indicators in Banten Province during the period of 2001–2010.

Water quality at Jongjing station: All water quality stations in this study were located at the same river tributaries; hence the last station in the downstream area (Jongjing station) would receive pollutants from the upstream stations. In the first part of analysis, we therefore explored the water quality data at Jongjing station, the lower most station in the downstream area, to assess the accumulation of water pollution brought by Ciujung River and its tributaries.

Nonmetal elements: There were nine physicochemical parameters out of 41 which showed an increasing pattern (Figure 5). Turbidity and total suspended solids (TSS), two water properties related with particulates contained in a water column (Kulkarni, 2011; Najah et al., 2009; Packman et al., 1999), have shown their increasing pattern. The concentration of these variables are greatly influenced by precipitation rate through runoff (Effler et al., 2007), but it can also be induced by contaminants such as heavy metals and pesticides (Bilotta and Brazier 2008).

Turbidity refers to the cloudiness or haziness of water generally caused by invisible particles (suspended solids) (Kulkarni, 2011). The standard limit for turbidity in the Indonesian river water is 25 nephelometric turbidity units (NTU). Meanwhile, the average value of turbidity at Jongjing station was of 68.83 ± 88.33 NTU. Some large fluctuations have accounted for the high mean value and standard deviation. The highest peaks were reached in December 2008 (577 NTU) and February 2010 (546 NTU), both occurred in the rainy season. TSS is a measure of the mass of solids (organic and inorganic) found in a volume of water that can be trapped using filter (Bilotta and Brazier 2008). The permissible limit for TSS in the Indonesian rivers is 50 mg/l. The range of TSS at Jongjing station from 10 years observation was 22 – 725 mg/l, with a mean value of 90.26 ± 107.37 mg/l. Except one peak in August 2000 (725 mg/l), the other two peaks of TSS occurred in December 2008 (615.5 mg/l) and February 2010 (577 mg/l), similar to the peak times of the turbidity. All oxygen-related properties *i.e.* dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD), has shown their intensifying trend. DO, as a relative measure of the amount of molecular oxygen that is dissolved in a given water volume (Lewis, 2006), decreased in concentration especially after 2006. BOD concentration, although still below its ambient level, showed some spikes in the last five years, meaning that the amount of dissolved oxygen needed by microorganisms for their oxidation process (the process of breaking down organic materials) (Cox, 2003) increased. Finally, the level of COD, as a measure of the amount of oxygen that is consumed by water in the decomposition of organic matter and oxidation of inorganic matter (Moreno-Casillas et al., 2007), was far above its ambient value (25 mg/l). The mean value of COD accounted from ten years data was 80.75 ±

85.01 mg/l. This value indicates that the amount of organic compounds contained in the water of Ciujung River was very high (Liu et al, 2009).

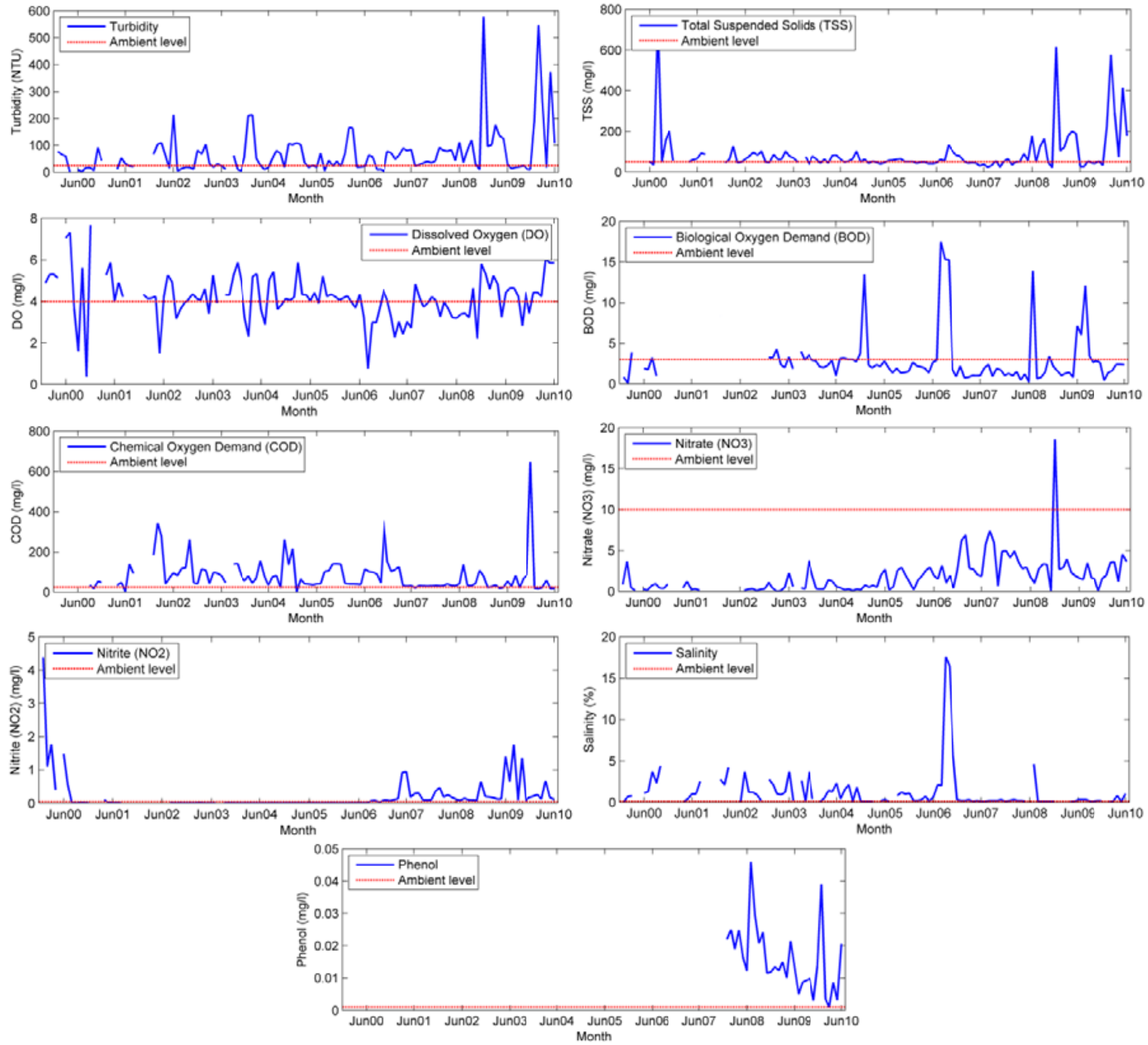
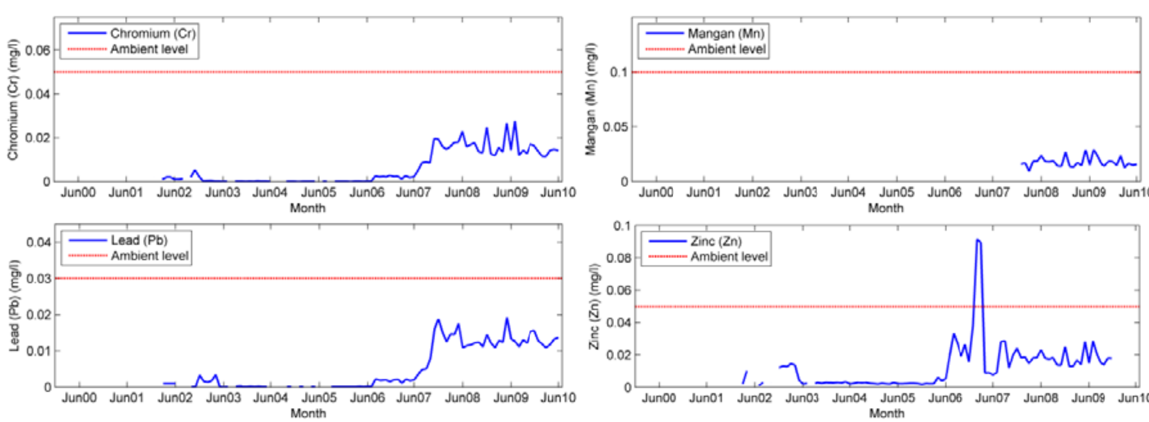


Figure 5.Concentration of nonmetal elements at lower most station in downstream area of Ciujung River (2000 – 2010).

All oxygen-related properties *i.e.* dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD), have shown their intensifying trend. DO, as a relative measure of the amount of molecular oxygen that is dissolved in a given water volume (Lewis, 2006), decreased in concentration especially after 2006. BOD concentration, although still below its ambient level, showed some spikes in the last five years, meaning that the amount of dissolved oxygen needed by microorganisms for their oxidation process (the process of breaking down organic materials) (Cox, 2003) increased. Finally, the level of COD, as a measure of the amount of oxygen that is consumed by water in the decomposition of organic matter and oxidation of inorganic matter (Moreno-Casillas et al., 2007), was far above its ambient value (25 mg/l). The mean value of COD accounted from ten years data was 80.75 ± 85.01 mg/l. This value indicates that the amount of organic compounds contained in the water of Ciujung River was very high (Liu et al, 2009). Nitrates and nitrites, two essential nitrogen-related properties frequently used for pollution indicator, also showed their magnifying concentrations. The mean concentration of nitrites (0.22 ± 0.54 mg/l) has exceeded its ambient level (0.05 mg/l). Its high concentration is also related with the high amount of organic materials in the water. The mean concentration of nitrates, although still below its ambient level, already indicated an escalating level especially in the last five years. Salinity refers to the water's saltiness and a measure of the mass of salts, such as carbonates, chlorides, nitrates, sulfates, potassium, sodium, magnesium and calcium, per unit mass of water (Pawlowicz, 2008). In pure fresh water, the salinity level should be close to 0.05%. In Indonesia, the ambient level in river water is determined not to exceed 0.1%. Meanwhile, the salinity at Jongjing station ranged from 0.08 to 1.60%, with a mean value of 1.24 ± 2.52%, far above its permissible level. Phenol concentration has exceeded its ambient level (0.001 mg/l). The monthly concentrations of phenol, which have been measured since 2008, produced a mean value of 0.016 ± 0.01 mg/l. The high concentration of phenol in the river water may be related to the high discharge of municipal and industrial sewages, such as dyes, detergents, drugs, polymers and organic substances (Michałowicz and Duda, 2007).

Heavy metal elements: Heavy metals are chemical elements which at high concentration are toxic to the environment and human. Domestic and industrial products, such as detergents, surfactants, insecticides, drugs and reagents, are among their original sources (Sakan et al., 2009; Rule et al., 2006; Patnaik, 2002). The 10-year measurement at Jongjing station showed an increasing trend in the concentrations of some heavy metals, but their average concentrations were still below the threshold limits, except for iron (Figure 6). Consecutively, the threshold level of chromium, manganese, lead, zinc, copper and cadmium in the Indonesian rivers are 0.05 mg/l, 0.1 mg/l, 0.03 mg/l, 0.05 mg/l, 0.02 mg/l and 0.01 mg/l. Meanwhile, their mean values at Jongjing station were 0.006 ± 0.008 mg/l, 0.018 ± 0.005 mg/l, 0.006 ± 0.006 mg/l, 0.013 ± 0.015 mg/l, 0.008 ± 0.006 mg/l and 0.008 ± 0.004 mg/l, respectively, all concentrations were still below their corresponding threshold levels. Iron was the only heavy metal element that exceeded its threshold level (0.3 mg/l) with its mean level of 0.39 ± 0.57 mg/l. Iron ions could be derived from natural sources and anthropogenic sources, such as domestic and industrial wastes. The escalating concentration of heavy metal elements, especially in the last five years, is very alarming to the environment. The trend is very obvious that without proper management the water quality in Ciujung River is going to be more declining in the short future. The sources of heavy metals are mostly related with the industrial wastes and the use of detergents, surfactants, emulsifiers and other daily human-related appliances.

Organic-material-related properties: The concentration of organic materials contained in water is also determined by potassium permanganate ($KMnO_4$) value, or so-called '$KMnO_4$ number', which is used to quantitatively determine the total oxidisable organic material in an aqueous sample (Patnaik, 2002). The ambient level of "$KMnO_4$ number" in the Indonesian rivers is 10 mg/l, Meanwhile the $KMnO_4$ number at Jongjing station ranged from 1.2 to 66.37 mg/l, with a mean value of 16.57 ± 12.64 mg/l (Figure 7). The high value of $KMnO_4$ confirmed the high contents of organic materials in Ciujung River as that predicted by the high COD value.



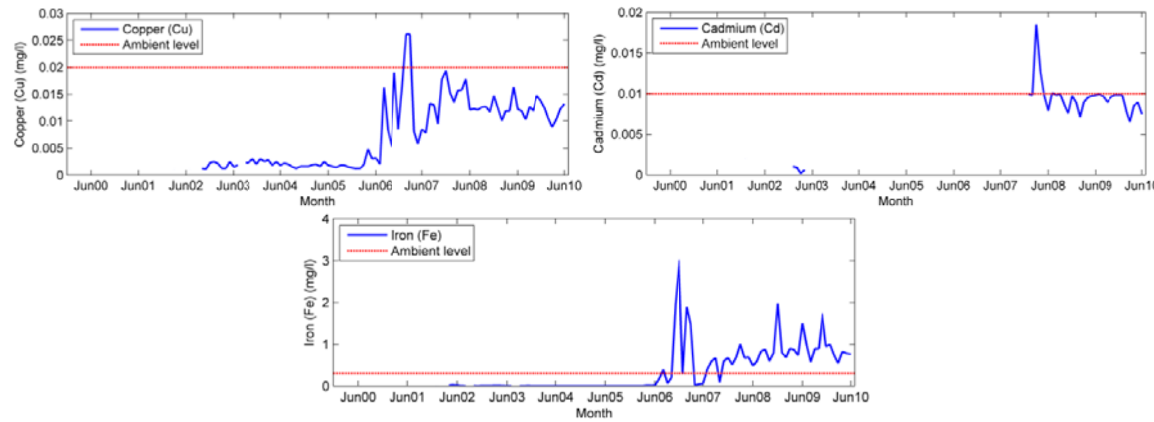


Figure 6. Concentration of some heavy metal elements at the lower most station in the downstream area of Ciujung River (2000–2010).

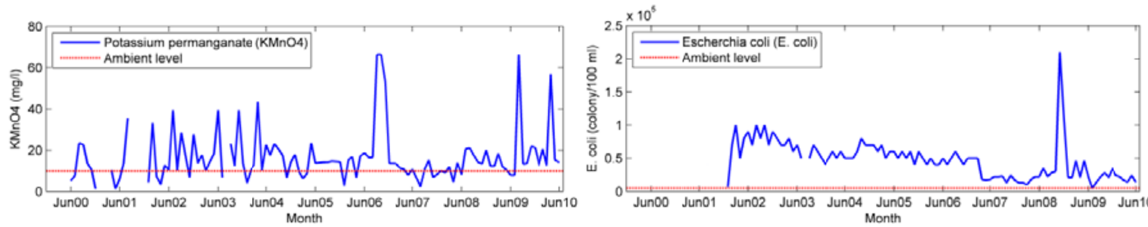


Figure 7. Concentration of organic-materials-related properties ($KMnO_4$ and *E. coli*) at lower most station in downstream area of Ciujung River (2000–2010).

In line with the high concentrations of KMnO4 and COD, as the indication of high organic material contents, the concentration of *Escherichia coli* (*E. coli*) at Jongjing station was also remarkably high. *E. coli*, as one most essential indicator of water healthiness, can have a long-term survival rate in river water up to 265 days at a temperature range of 4 – 25 ºC (Flint, 1987). The expectable limit of total *E. coli* in the river water in Indonesia is 5000 colonies / 100 ml. Meanwhile, the mean concentration of *E. coli* at Jongjing station has reached 47,749 ± 28,906 colonies / 100 ml, with a range of 4,400 to 210,000 colonies / 100 ml. The excessive concentration of *E. coli* could be related to the unhealthy culture of some local people, especially those living below the poverty level. Their retain less care on the installation of septic tank in their houses and just simply flushing all waste water away from toilets, bath rooms, washing places and livestock farming to the drainage or river without having treatment, is very common. The concentration of *E. coli* had been very high even before the decentralization policy. Fortunately, during the 8 years, the *E. coli* concentration exhibited a declining trend. The results may be coincident, but it could be a result of the intensive sanitation programs, such as sanitation by communities (Sanimas) and water and sanitation for low income communities (WSLIC) programs. Both programs have constructed a big number of public toilets and sanitary systems in some urban and rural areas in Indonesia, including in Banten Province (Buhl-Nielsen et al., 2009). However, many efforts are still required to reduce this pathogen bacteria concentration until below its ambient level.

Multivariate Statistics Analysis

Cluster analysis*:* HCA was performed to identify the similarity groups between six years monthly average water quality data. The dendrogram (Figure 8), as a result of HCA, illustrates the seasonal grouping of all 25 variables. The monthly average water quality data were classified into four statistically significant clusters at (Dlink/Dmax) < 15, including Cluster 1: February, March and January; Cluster 2: April, June and May; Cluster 3: July and August; and Cluster 4: September, October, November and December.

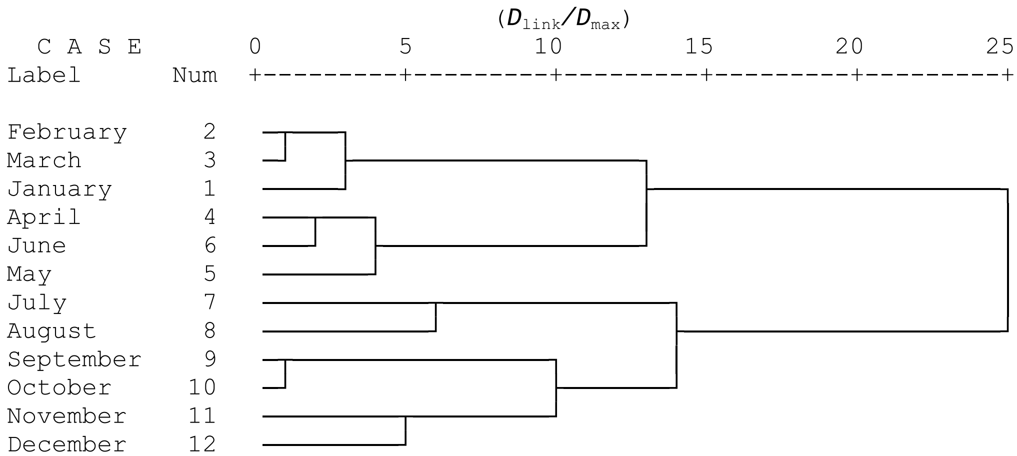


Figure 8. Agglomerative hierarchical clustering based dendrogram using Ward's method and Euclidean distance showing seasonal grouping

Based on Schmidt and Ferguson classification, in which rainfall intensity is used as a main factor for climatic classification, Indonesia consists of two main seasons, i.e., dry season and wet/rainy season, including their transition periods. In Java, dry season usually occurs between July and September (Aldrian and Susanto, 2003), with the midpoint in August (Hendon, 2003), whereas the peak time of high rainfall intensity normally occurs in December (Aldrian and Susanto, 2003) or January (Hendon, 2003). The other months are considered as transition periods. However, those periodical classifications are sometimes slightly different from one year to another, because they are influenced by the events of El Nino and La Nina (Hamada et al., 2002). It is obvious that the yielded clusters indicate that the changes of water quality in the study site were significantly affected by the seasonal variability, in this case the rainfall intensity and river water debit. This study has demonstrated that CA has an advantage in exploring some meaningful information out of the complex dataset that could not be able to be figured out by the simple statistics in the previous section.

Factor analysis: PCA followed with FA, was applied to the Kaiser-normalized full dataset. The rotated Varimax component matrix of five VFs was produced as that listed in Table 2. Based on Unmesh et al. (2006), the absolute loading values are classified into three classes, i.e., <0.4, 0.50 – 0.75 and > 0.75, corresponding to weak, moderate and strong loads.

Table 2. R-mode rotated varimax factor analysis of water quality parameters

Parameter	Varifactor				
	1	2	3	4	5
TDS	.919	.072	-.051	-.050	.007
DHL	.903	.041	-.077	-.048	-.061
COD	.588	-.046	-.008	.130	-.075
Chlorida	.588	.187	.096	-.050	.184
Total_Hardness	.569	.160	.126	-.104	.549
Salinity	.551	.416	.059	.040	.207
Sulfate	.551	-.211	-.356	-.023	-.233
Calcium	.528	.483	.113	-.039	.435
Alkalinity	.132	.852	-.155	-.067	.059
BOD	.113	.753	-.142	.057	.167
DO	-.006	-.552	-.167	.283	.213
Temperatur	.006	.477	-.238	-.137	-.086

Copper	.016	-.085	.881	-.002	.018
Iron	.081	-.187	.733	.211	.067
Zinc	.041	.141	.565	-.144	-.441
Chromium	-.076	-.422	.563	.199	.469
Lead	-.079	-.412	.519	.162	.462
Nitrite	-.072	-.019	.313	.121	.164
TSS	-.007	-.158	.194	.875	.141
Turbidity	-.064	-.148	.174	.872	.000
Nitrate	-.035	-.154	.366	.525	-.037
E.coli	.076	.084	-.131	.371	-.186
Magnesium	.150	.041	.028	-.131	.614
Permanganate	.035	-.233	.019	.217	.483
pH	-.079	.147	.080	-.084	.422
Eigenvalue	4.874	3.768	2.075	1.632	1.590
Total Variance (%)	19.498	15.074	8.299	6.527	6.361
Cummulative variance (%)	19.498	34.572	42.871	49.397	55.758

VF 1, accounting for 19.50% of the total variance, was strong positively loaded with TDS and EC and moderate positively loaded with COD, chloride, total hardness, salinity, sulfate and calcium. It is clear that these variables were believed to be related to mineral loads from runoff and soil erosion. The results also implied that rainfall intensity was the key factor which influences the variability of water quality in Ciujung River. The next variables, which were grouped in VF 2 and accounting for 15.07% of the total variance, including alkalinity, BOD, DO and temperature, were also believed to be related to the rainfall variability and water debit. Except for DO, which was moderate negatively loaded in VF2, alkalinity, BOD and temperature were positively loaded with the loading values ranged from moderate to strong. Most of the water variables which were grouped in VF 3, which accounted for 8.30% of the total variance, were heavy metals and nitrite, with the loading values ranged from moderate to strong positive. These elements, whose their existence at high concentration is poisonous to the environment, seemed to be related to the anthropogenic discharges and wastes, including those coming from industry. Although their contribution to the variability of Ciujung River was still very limited, as that proved by only 8.30% of the total variance, but their emerging trend was important to be intensively monitored along with the economic development trend. VF 4 and VF 5, each accounting for 6.52% and 6.36%, consisted of TSS, turbidity, nitrate, *E. coli*, magnesium, KMnO4 and pH. Although clear explanation for the relationships between these variables could not be taken, both natural loads and organic materials as response to the rainfall intensity and anthropogenic impact may have been the reason behind these variables grouping. Again, this study has showed that FA/PCA was powerful to figure out some useful information out of the complex dataset that could not be possible to be overcome by the standard statistics.

CONCLUSION

One decade after the implementation of decentralization policy in 1999, Banten Province has gained considerable economic growth. The GDP contributed to approximately 14.75% of the national GDP in 2010. Industrial sector contributed to more than 50% of the GDP. By these achievements, it is therefore important to assess the water quality in Ciujung River for sustainability reasons. Ten years of monthly water quality data comprising of 41 parameters from nine stations were used for the analysis wherein multivariate statistics analysis including CA, FA and PCA were applied. The analysis was done at Jongjing station (the lower most station in the downstream Ciujung, into which the river water accumulates). The results showed that the majority of the parameters were still below their threshold values. However nine physicochemical elements, seven heavy metal elements and two organic-material-related properties have shown the increasing trends. For nonmetal elements, there were eight parameters already beyond their ambient values, including turbidity, TSS, COD, salinity, nitrite, phenol, KMnO4 and *E. coli*. Overall, this study revealed that Ciujung River is still considered to be relatively clean, but an emerging increase in heavy metals concentration could be taken as a serious warning. The result of CA in multivariate statistics shows that the monthly average of water quality data was grouped in four clusters: Cluster 1: February, March and January; Cluster 2: April, June and May; Cluster 3: July and August; and Cluster 4: September, October, November and December. The produced clusters indicate that the changes of water quality were highly affected by seasonal variability, in which the rainfall intensity became the primary key. The PCA/FA produced four dominant varifactors. VF 1, accounting 19.50% of the total variance, was strong positively loaded with TDS and EC and moderate positively loaded with COD, chloride, total hardness, salinity, sulfate and calcium. VF 2, accounting for 15.07% of the total variance, includes alkalinity, BOD, DO and temperature. VF 3, accounting for 8.30% of the total variance, comprises all observed heavy metals and nitrite, with the loading values ranged from moderate to strong positive. Although their contribution to the variability of Ciujung River was still very limited, as that proved by only 8.30% of the total variance, but it is important to anticipate their future increase along with the economic development trend. VF 4 and VF 5, each accounting for 6.52% and 6.36%, consist of TSS, turbidity, nitrate, *E. coli*, magnesium, potassium permanganate and pH.

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CONFLICT OF INTEREST : Nothing