ABNORMAL MICROFAUNAL SHELLS AS EARLY WARNING INDICATOR OF ENVIRONMENTAL CHANGES SURROUNDING BERAU DELTA, EAST KALIMANTAN

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ABSTRACT

A total of 25 sediment samples from surrounding Berau Delta, East Kalimantan have been used for microfaunal study. It is found some abnormal shells of ostracoda, foraminifera and other forms with darkish shells (black, dark green and dark brown). These forms were analyzed using SEM-Energy Dispersive X-ray spectroscopy (EDX or EDS) to know their chemical composition. The result shows that these abnormal forms composed of CaO, SiO_2, C, FeO, Al_2O_3, K_2O, and small amount of Na_2O and Cl. They may derive from different sources: CaO and MgO from neutralized component during the environmental management to handle the Acid Mine Drainage (AMD). The other components may derive from coal ash during combustion process or other activities. From this result, the small amount (less than 5%) of abnormal shells may be used as early warning indicator of environmental changes in the study area.

Keywords: abnormal microfaunal shells, chemical composition, Berau Delta.

SARI

Sebanyak 25 sampel sedimen dari sekitar Delta Berau, Kalimantan Timur telah digunakan untuk studi mikrofauna. Ditemukan cangkang abnormal dari ostracoda, foraminifera dan spesimen bentuk lain dengan cangkang kegelapan (hitam, hijau tua dan coklat tua) Bentuk-bentuk ini kemudian dianalisa menggunakan SEM-Energy Dispersive X-ray spectroscopy (EDX or EDS) untuk mengetahui komposisi kimiawinya. Hasilnya menunjukkan bahwa cangkang-cangkang mikrofauna yang abnormal ini mengandung CaO, SiO_2, C, FeO, Al_2O_3, K_2O, dan sedikit kandungan Na_2O dan Cl. Komponen ini kemungkinan mempunyai sumber yang berbeda: CaO dan MgO mungkin berasal dari bahan penetral selama pengelolaan lingkungan untuk mengatasi air asam tambang (AMD). Komponen lain berasal dari abu batubara saat proses pembakaran atau aktivitas lain. Jumlah cangkang abnormal yang sedikit (kurang dari 5%) ini kemungkinan dapat digunakan sebagai indikator peringatan dini adanya perubahan lingkungan di daerah penelitian.

Kata kunci: cangkang mikrofauna abnormal, komposisi kimiawi, Delta Berau

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INTRODUCTION

The study area is located in northern part of East Kalimantan that has incredible coastal and marine potential resources such as third highest reef diversity in the world. It extends from several rivers surrounding Berau delta toward small islands in an offshore area of Makassar Strait. One of the islands, Derawan, is a famous place as tourism destination and it is believe being a relatively pristine environment. Based on Regulation of Berau Regent No 31/ 2005, the study area has been established as a Marine Conservation Area. On the other hand, a wide range of economic activities in this area is also relatively dynamic such as on coal mining, pulp and maritime industries: ship docking, coal transshipments etc.

Those activities indirectly will influence the river systems that flow into the coastal and marine environments. It has seems by increasing suspended material surrounding Berau Delta from 1994 to 2002. It is related to destruction of mangrove area for prawn and mining activities that indirectly effect on coastal environmental changes (Parwati *et al.,* 2007). Therefore, many monitoring programs are being done to protect this area as pristine as natural condition. One of the monitoring tools is by using biological aspect beside chemical and physical factors. The biological aspects such fish, sea grass, mangrove and reef conditions are commonly used as environmental indicators. It is less study on microfaunal assemblages as applied in many areas in the world.

Microfaunal shells (foraminifera and ostracoda) from offshore areas of East Kalimantan have been studied by Carbonel (1983); Boichard, *et al* (1985), Dewi and Illahude (2005) and Gustiantini *et al* (2005). They found some abnormal shells of ostracoda, foraminifera and other forms with blackish dark colored specimens (black, dark green and dark brown). Some of their shells are filled by very fine dark grains of unknown materials. They assumed that these abnormal specimens were related to the occurrences of chlorite and glauconite (smectite). Based on this uncertain result, therefore we analyze the specimens in order to recognize their chemical compositions that made abnormal specimens to know the source of pollutants.

The abnormal shells have been studied by many scientists but most of them focused of the abnormalities of wall textures, deformed tests, and other morphological shells related to environmental changes. Geslin, *et al* (1998) have observed specifically on many deformed specimens of *Ammonia* that caused by change of physical and chemical parameters. Furthermore, Samir (2000) reported the presence aberrant specimens in the lagoon of Mazalah, Egypt that are related to the nature of the pollutants. High concentration of heavy metal caused abnormal growth and the occurrences of twinned small size of chambers due to high agricultural runoff drainage water into his study area. The present study concentrates on the abnormal color of microfaunal shells.

METHODS

A total of 75 sediment samples were carried out by using a grab sampler and a gravity corer by RV Geomarin 1 in 2003 and 2005. Twenty five of them have been selected for microfaunal assemblages in relation to bathymetric zonation (Dewi and Illahude, 2005). During this study, it is found many (less than 5%) abnormal specimens that composed of ostracoda, foraminifera and other forms. They were collected and picked among sediment particles under a binocular microscope. Then, all abnormal specimens were placed in a stub, coating and then photographed by using Scanning Electron Microscope in a Quaternary Laboratory, Centre of Geological Survey. With the same machine, subsequently the selected surface

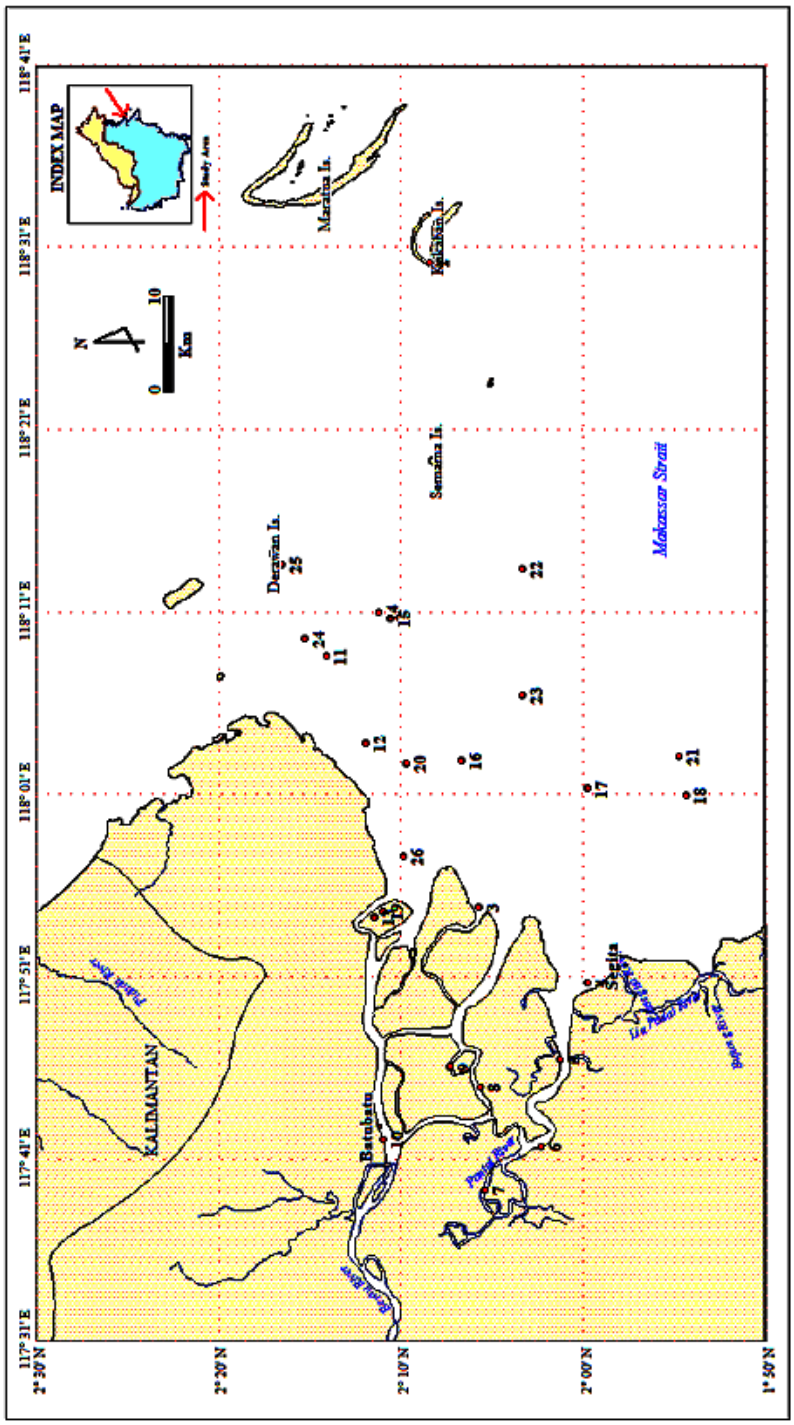

Figure 1. Sampling locations of the study area

area of specimens was analyzed by using Energy Dispersive X-ray spectroscopy (EDX or EDS). It is an analytical technique used for element characterization or elemental analysis of a sample. This method can be tested several times based on the appearances of different color in one specimen. The elemental composition of every analyzed area or specimen will appear directly on the monitor as EDX spectrums.

Ten specimens of foraminifera, ostracoda and another form have selected for this study and each specimen was examined between once and three times. *Asterorotalia trispinosa*, two species of *Elphidium*, *Cibicides* sp and *Globorotalia menardii* are representative of foraminifera. Ostracoda is taken from genera *Bairdopillata*, *Keijella multisulcus* and *Phlyctenophora orientalis* as indicative inhabitant of shallow marine environment. Another form of sedimentary particle is also analyzed by EDX to know its chemical characterization.

RESULTS AND DISCUSSIONS

A total of 20 selected area from ten specimens have been examined by using EDX as seen in Table 1 based on selected area of each specimen (Figure 2). The chemical composition consists of C, SiO_2, CaO, Al_2O_3, MgO, FeO, K_2O, Na_2O and Cl with diverse amount for every component as follow.

All of the examined specimens (20 surface selected areas of specimens) compose of carbon between 6.72 and 74.19%. The lowest percentage is found in an ostracod specimen of *Keijella* and the highest value occurs in *Elphidium* as represented of benthic foraminifera. This carbon may derive from coal material or particles that spread and accumulated in coastal and marine sediments surrounding the study area. According to the morphological shells, it seems that the high content of carbon is accumulated in a surface shell with holes or crack blackish shells. It is seen in ostracod species, *Phlyctenophora orientalis* that was examined in three different areas (Figure 3). The result shows that the darkness area (Figures 3G and H) has highest content of C (47.37%) than two other areas. In another specimen of *Elphidium*, the content of C in surface shell is 29.53% but its value reach 74.19% in a narrow part of sutures or chambers.

According to Boltovskoy and Wright (1976), the calcareous foraminiferal shells such as *Elphidium* compose of $CaCO_3$, $MgCO_3$, $FeCO_3$ and SiO2. These components are also found in ostracod shell but it is more complex (25 trace elements) with the most common one being Mg, Sr, K, and Ba (Bodegart and Andreani, 1981 in De Deckker and Forester, 1988).

Based on those previous studies, it seems that the content of carbon in all analyzed specimens show as unusual component. Therefore, it can be assumed the carbon as a reliable indicator of the amount of coal in the sediment. Carbon (C) is the main organic elements of coal beside hydrogen (H), oxygen (O), Nitrogen (N) and sulfur (S) due to its origin from plants. It is also supported by the fact that coal materials have been loss 2-3% during the transshipment from the source to other areas through the rivers and open sea (Ishlah and Fujiono, 2004). It may be deposited in the surface sediments surrounding the Berau Delta that indirectly influence the benthic organisms including foraminifera and ostracoda.

Almost all specimens contain of SiO_2 between 6.66% and 55.32 % with exception zero points in three samples. The content of SiO_2 is one component that is originally found in microfaunal shells with variable composition. The low values less than 10% occur in several specimens and most of them have values more than 25% in surface shells of

Table 1. Chemical composition of microfaunal shells based on EDX analysis

No.	Sample codes of analyzed area	Abnormal specimens	Chemical compotition								
			C	SiO_2	CaO	Al_2O_3	MgO	FeO	K_2O	Na2O	Cl
1	1A	Foraminifera (*Asterorotalia*)	14.29	35.02	21.96	11.93	1.86	12.43	2.51		
2	1B	Foraminifera (*Asterorotalia*)	8.08		91.92						
3	1C	Foraminifera (*Asterorotalia*)	12.21		87.79						
4	2A	Foraminifera (*Elphidium* sp. 1)	74.19	13.77	4.12	7.91					
5	2B	Foraminifera (*Elphidium* sp. 1)	29.53	6.75	50.88	4.92	7.91				
6	3A	Foraminifera (*Ammonia*)	13.97	28.56	21.11	11.17		22.46	1.74	1.10	
7	4A	Foraminifera (*Elphidium* sp. 2)	8.88	55.32	12.89	10.56	4.20	9.15			
8	4B	Foraminifera (*Elphidium* sp. 2)	12.02	32.49	28.28	16.05	5.98	5.19			
9	4C	Foraminifera (*Elphidium* sp. 2)	8.53	51.29	3.75	23.40	3.58	6.49	2.95		
10	5	Foraminifera (*Cibicides*)	14.00	7.58	77.65						0.78
11	6A	Planktonic foraminifera	11.53	41.64		6.57	5.07	35.19			
12	6B	Planktonic foraminifera	15.79	10.39	73.81						
13	7A	Ostracoda (*Bairddopilata*)	17.35		75.74	4.10				1.77	1.05
14	8A	Ostracoda (*Phlyctenophora*)	10.95	45.95	7.70	20.53	7.92	5.07	2.35		
15	8B	Ostracoda (*Phlyctenophora*)	11.24	8.53	62.22	4.61	7.40				
16	8C	Ostracoda (*Phlyctenophora*)	47.37	6.66	41.90		5.58				
17	9A	Ostracoda (*Keijella)*	6.72	51.13	5.41	19.62	2.43	11.60	3.19		
18	9B	Ostracoda *(Keijella)*	13.43	29.26		12.33	11.37	39.60			
19	9C	Ostracoda (*Keijella)*	11.91	28.45	28.28	14.70	6.29	10.37			
20	10	Rounded particles	12.30	50.29		5.36	3.91	24.37	3.66		

foraminifera, ostracoda and uncertain form. Two of the zero point occurs at the same specimen of *Asterorotalia trispinosa* but in another area has 35% of SiO_2. This is due to different chemical composition in which the zero point areas have been filled with high content of CaO (87-91%). It can also be observed in another specimen of ostracoda (*Bairdopillata*) that does not compose of SiO_2 but it is replaced by the high amount of CaO (75%).

The content of CaO can be found in 17 samples with values between 3.75% and 91.92%. Only four samples have low value less than 10% and seven samples have value more than 50% of CaO. Calcium (Ca) is an originally main component for constructing the microfaunal shells but in elemental form of carbonate calcium (CaCO3) not oxide calcium (CaO) as appear in these present samples. Other chemical components of Al_2O_3, MgO and FeO are varied between 2.43 % and 39.60%. The high value of Al_2O_3 (more than 20%) occurs in *Elphidium* and *Phlyctenophora*.

The MgO is detected in 13 samples that have values less than 8 % with an exception in one sample 9B (*Keijella*) that has 11.37%. The value of FeO more than20% occur in four selected samples and the other 7 samples contain of FeO less than 13%. The rest three chemical elements, K_2O, Na_2O and Cl are found in small amount less than 4%. Chlorine (Cl) although in very small amount but it is one of the several pollutants that is usually used for bleaching of wood pulp.

The values of all chemical components are then summed and divided into the number of

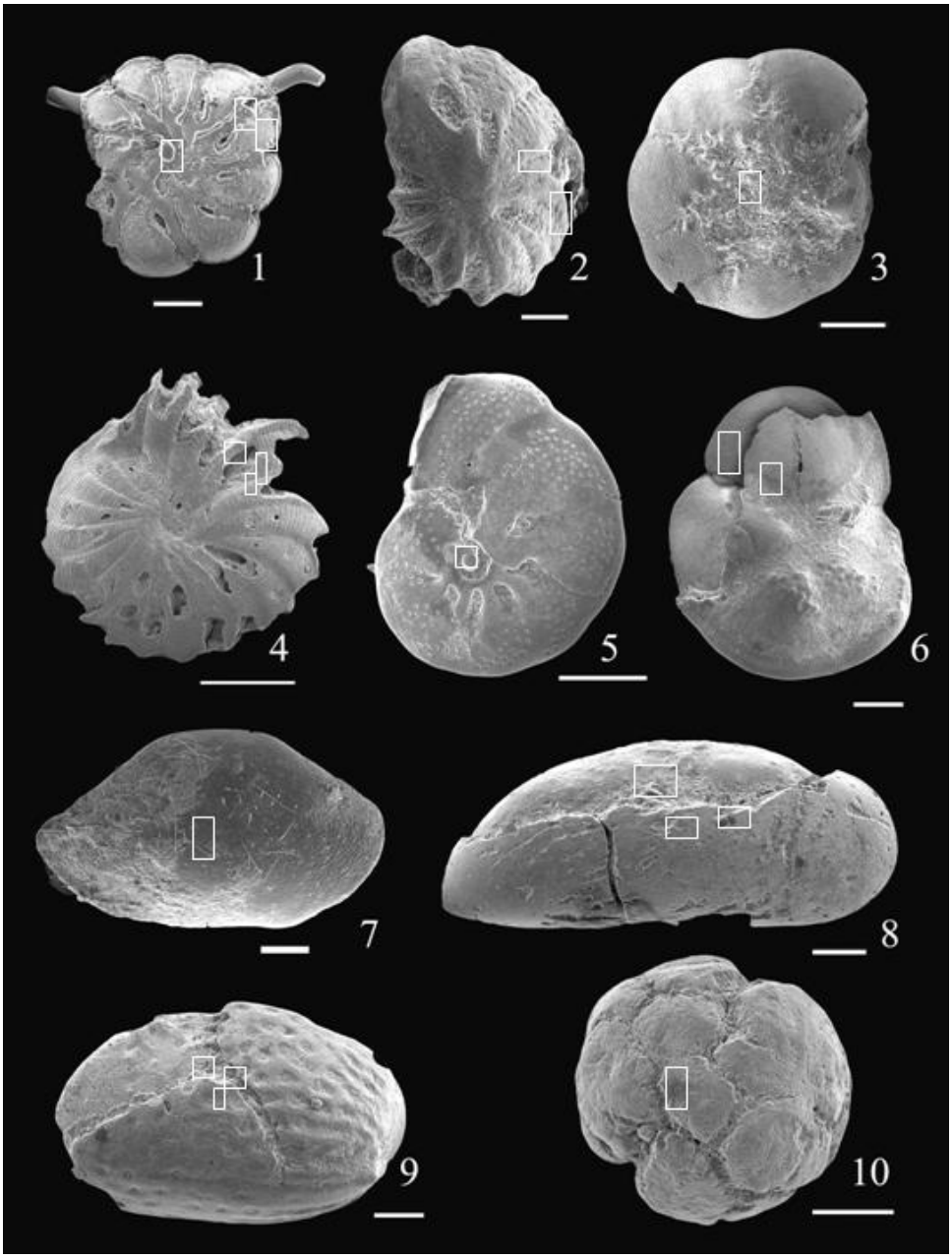

Figure 2. Abnormal samples with selected areas (white boxes) for tracingchemical composition. Name of specimens appear in Table 1.

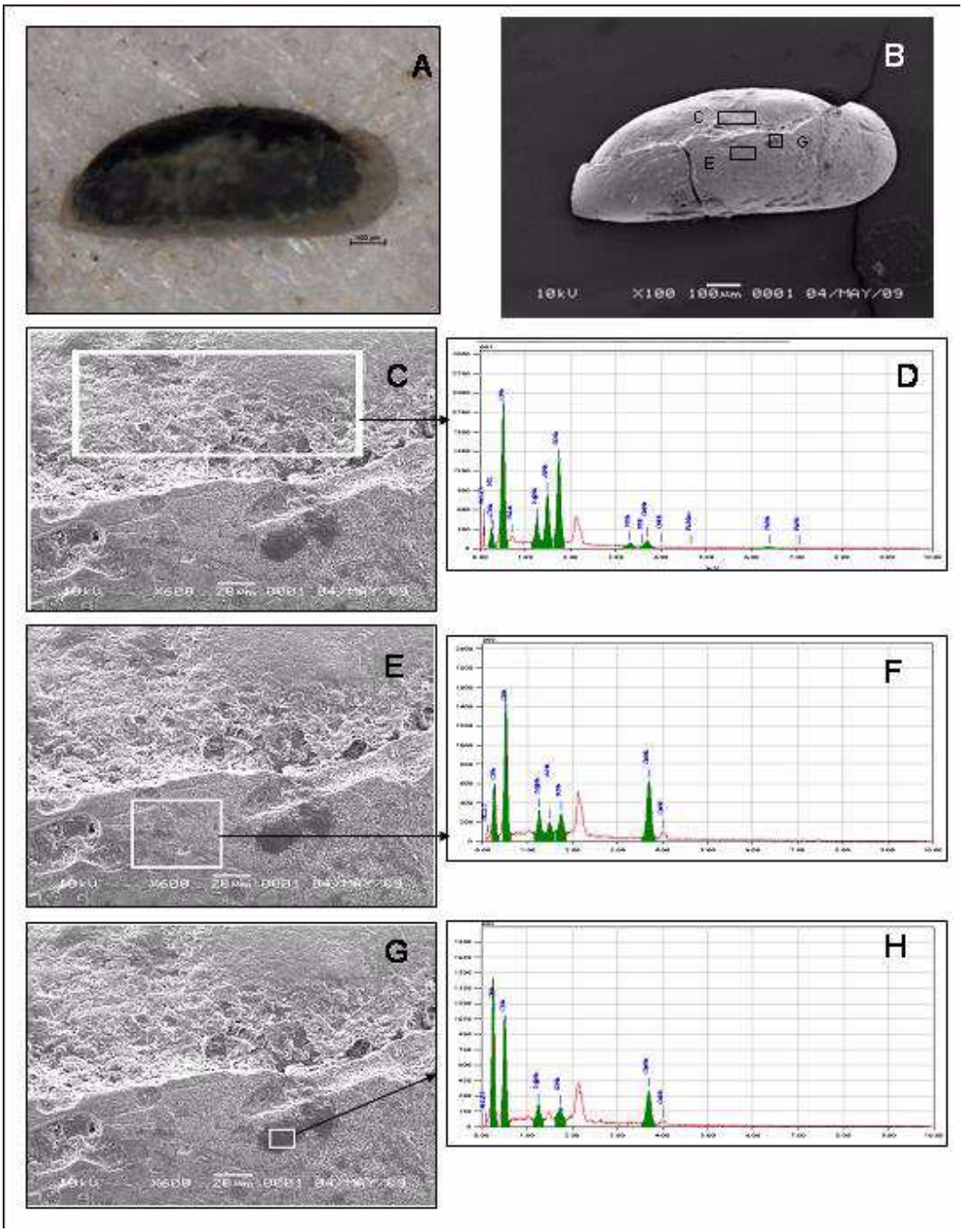

Figure 3. An example result of examination with EDX methods. Photographes used a binocular microscope (A) and Scanning Electron Microscope (B). A single specimen ostracoda, Phlyctenophora orientalis tested in three different areas (C, E, and G) that were resulted their EDX spectrum of minerals (D, F, and H).

samples to know the average value as showed in Figure 4. It seems that the CaO reach the highest concentration compared with others. The high concentration of CaO occurs in almost analyzed specimens and it varies between 3.75% and 91.92%. As mentioned above that $CaCO_3$ is the originally component for constructing the microfaunal shells, therefore the detection of CaO in most speciment is as uncommon component. The amount of this element may relate to the using of CaO (oxide calcium) for neutralizing the content of acid mine drainage (AMD). This is used beside $CaCO_3$, MgO and Ca $(OH)_2$ in Berau Coal Mining (Untung and Rosnia, 2009).

The occurrences of other chemical elements in the microfaunal shell are also may related to the component of coal ash that are small and light enough to be distributed in the study area or may from other sources. It is known that this ash consists of Si, Al, Fe and small amount of Ti, Mn, Mg, Na, and K. The characteristic of coal ash depends on the characteristic of their chemical element during the combustion process (Rance, 1975 in Sumaryono 2009). The high content of CaO, MgO and Fe_2O_3 cause decreasing melting point of ash especially if SiO_2 is quite high. Other components of Na_2O and K_2O can also decreasing melting point of ash. The high melting point related to high content of Al_2O_3 and SiO_2 that can produce solid ash and it will be difficult to be displaced as bottom ash (Sumaryono, 2009).

CONCLUSIONS

The abnormal brown to blackish color of microfaunal shells composed of CaO, SiO_2, C, FeO, Al_2O_3, K_2O, and small amount of Na_2O and Cl. They may derive from different sources: CaO and MgO from neutralized component during the environmental management to handle the AMD. The other components may derive from coal ash during combustion process or other activities. The occurrence of abnormal shell in small amount compared with the normal and beautiful forms, it can be used as early warning indicator of environmental changes in the study area.

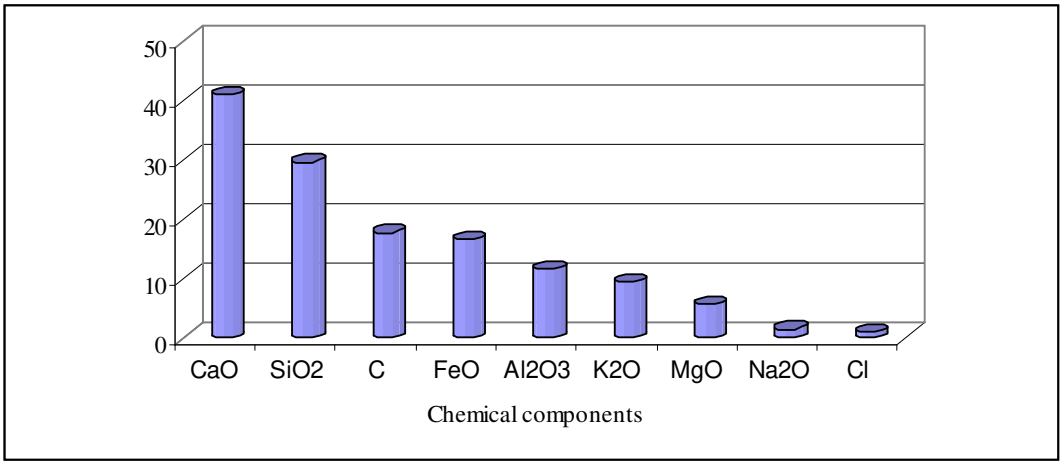

Figure 4. The chemical components of microfaunal shells from highest to lowest contents

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