

Pollen and Foraminifera Approaches to Identify Sediment Sources In The River Mouth Mahakam East Kalimantan

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Received: Sept 1, 2017. Revised : Oct 1, 2017, Accepted: Nov 9, 2017, Published: 1 Dec 2017

DOI : 10.24273/jgeet.2017.2.4.689

Abstract

The central role of Mahakam River in the construction of Mahakam Delta is to supply sediment from terrestrial to the river mouth. The river upstream comes from Mount Camaru and the downstream part terminate at Makassar Strait. The surrounding area of the river is overgrown by wet tropical flora that produces pollen. The existence pollen in river sediments as an indicator that sediment came from terrestrial, and foraminifera as an indicator that sediment came from marine. The ratio changes of pollen to foraminifera show that there were differences of sediment source supply. The study was conducted at the river mouth. A shallow core, 200 cm depth, composed of sand and mud and sandy mud, from it taken vertically 11 samples to be analyzed pollen and foraminifera. Sample preparation was using standard methods acetolysis. Meanwhile, sample preparation of foraminifera using Hydrogen Peroxide method. Pollen found in all samples, but foraminifera only found in 8 samples. The data indicating that sedimentation process in the mouth of a river not only gets sediment supplies from terrestrial but also from marine. The quantity of pollen and foraminifera varies vertically. The frequency of pollen much higher than foraminifera that indicates of source sediments dominance came from terrestrial which carried by Mahakam river current. *Sonneratia caseolaris* pollen continuously found in all samples. *Stictogonylus vandiemensis* is species foraminifera the most common that followed by *Ramulina confossa*, both of them come from the sea particularly from the shallow sea.

Keyword: Pollen, foraminifera, sediment source, mouth of Mahakam River

1. Introduction

The river mouth is the place where a river enters a lake, larger river, or the ocean is called its mouth (Merriam-Webster, 1828). The Mahakam River is an icon for the Province of East Kalimantan. Mahakam River upstream rises in Mount Cemaruru that empties into the Makassar Straits. The position of a river mouth in the upstream from Mahakam Delta. The main role of the Mahakam river in the delta formation is supplying sediment to the estuary area.

The Province of East Kalimantan, the place of Mahakam River is located in the equatorial area (Fig.1).

The landscape along the Mahakam River overgrown by various types of tropical flora. In the upstream section, there are hilly areas that inhabited by tropical rainforest that located in the district of Mahakam Hulu.

Mahakam river is generally covered by vegetation of lowland forest and mixed forest. Entering the delta plains area there are swamp forests which dominated by *Nypa fruitcans* and secondary mangrove plant, the true mangrove

grows at the end of the delta plains, precisely in the area of mud flats (Winantris, et.al 2013, Fig.2).

The existence of tropical forest plants along the river, makes sediments transported to the estuary filled with pollen which produced by forest plants. This is one reason why research is done. The study aims to identify the types of pollen found in sediments that before entering the Mahakam delta. It is important to know the type of pollen that fills a river as a tool to identify the source of sediment deposited at the mouth of the river before entering delta area. Benthic foraminifera classically used as an indicator of marine depositional environments, in particular, to detect the ocean depths (bathymetry), it is closely related to the way of living foraminifera are attached to the seabed. Both pollen and benthic foraminifera have a similar function in this case for identifying the source of sediment. The Mahakam delta is a mixed, river and tide-dominated delta (Galloway, 1975). The delta characterized by a mixture of sediment from the river and the sea. Furthermore, the delta is presently in a transgressive phase (Salahuddin and Lambiase, 2013). Tide rise in Mahakam Delta

triggered by the waves that come from the Makassar Straits which cause water accumulation in the delta plain area (Allen and Chamber, 1998). High tides are also as transport media of sediment from the sea to the delta region

Evidence that the tide rise could encourage marine sediments towards the river mouth by looking for the presence of foraminifera in sediment. Kind of foraminifera is an indicator of the marine bathymetry of the origin sediments. Referring to the bathymetry and habitat

classification of benthic foraminifera, it will be known the depth of sedimentary origin which is transported and deposited at the mouth of the river comes. Likewise, the source of sediments that comes from upstream can be traced by the pollen data. Pollen analysis is one of foundation for reconstructing past ecosystems, by fossil pollen preserved within accumulating sediment whose provenance can be identified back to the parent plant (Lovett, et.al 2007).



Fig.1 Location of Mahakam River (Duxbury, 2010)

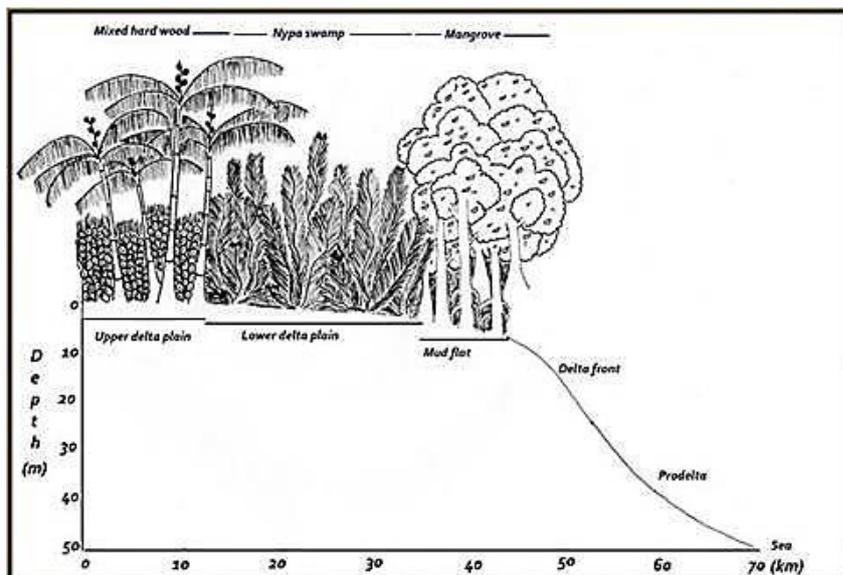


Fig. 2 Vegetation zone of Mahakam Delta (Winantris, et.al.2013).

2. Material and Methods

A shallow core taken at the mouth of the Mahakam river with a depth of 200 cm, from it taken 11 samples at intervals of 20 cm for the analysis of pollen and foraminifera, consist of: MR-1 (0 cm), MR- 2 (20cm), MR-3 (40cm), MR-4 (60cm), MR-5 (80cm), MR-6 (100cm), MR-7 (120cm), MR-8 (140cm), MR-9 (160 cm), MR-10 (180cm) and MR-11(200cm). The position of sample location at Mahakam River upstream from the delta (Fig.3).

Sample preparation for the palynological analysis was done using acid treatment method. Each sample was taken 10-gram dry weight for pollen analysis, and only 0,5 ml/slide from the residue of the sample that observed. Identifying pollen used light binocular microscope under high magnification x100, 400x and 1000x, and scanning electronic microscopy. Pole observation used LO analysis method. To get a clear pollen morphology the picture was taken under magnification 1000x. The same as pollen treatments, for the analysis of foraminifera are also using 10 gr dry

weight/sample. Processing sample of foraminifera used Hydrogen Peroxide method, and for observation using a binocular microscope. Identification of foraminifera refers to [Loblich & Tappan \(1994\)](#). Meanwhile, the ocean depths refer to the classification of bathymetry ([Tipsword et al 1966](#)), see Fig 4.

3. Pollen analysis

The shallow core consists of sand and silt sediment, from a depth of 200 cm to 131cm consists of fine sand, medium and coarse sand. From the depths of 131cm up to the surface at position 0 cm composed of silts and clay. All samples which analyzed found the pollen. The total pollen sum of sand sediment only 30 to 70 grains in each sample, that include the poor to moderate category, and average just 51,2 grains/sample. Different from silt sediment, pollens found more than in sand sediment. Minimum pollen is 126 grains at MR-3 and maximum 256 grains at MR-4, pollen average reach 210,83 grains, it's belong rich category (Table 1 and Fig.7).

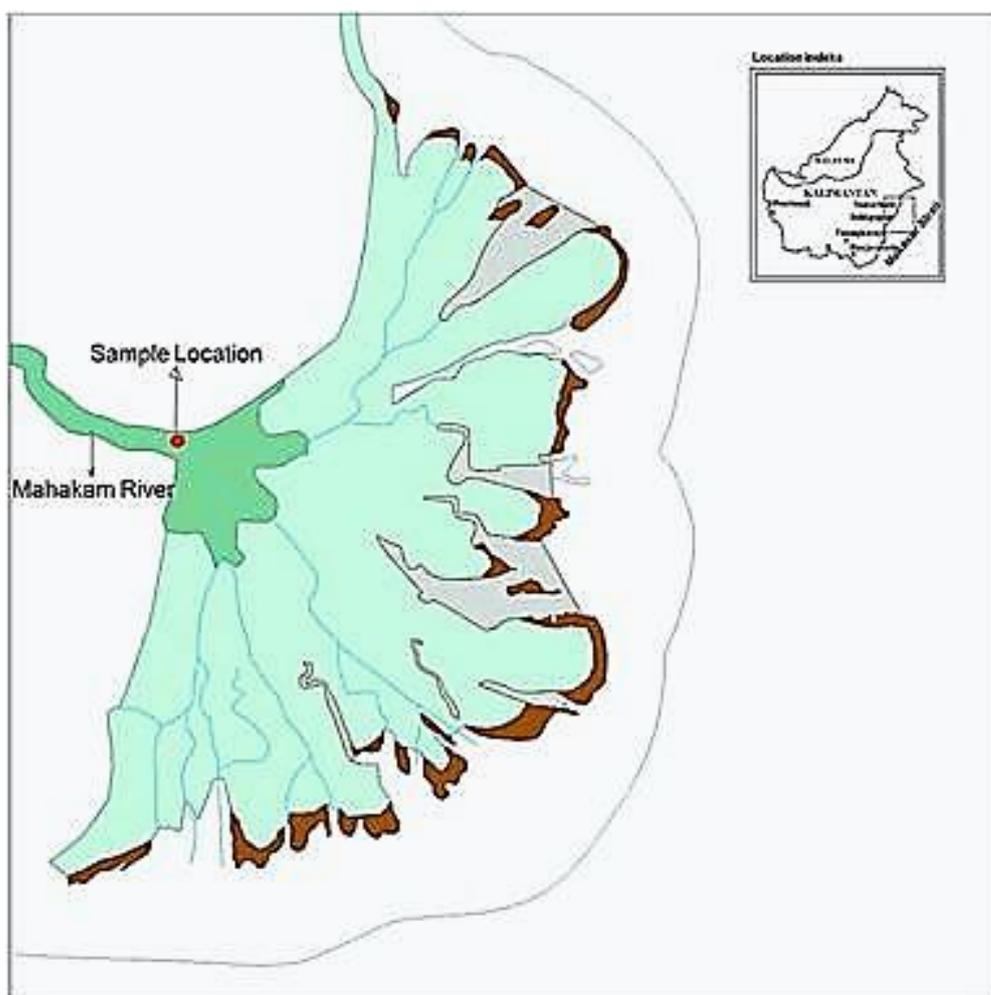


Fig 3. Spot location of study at Mahakam River, Kalimantan.

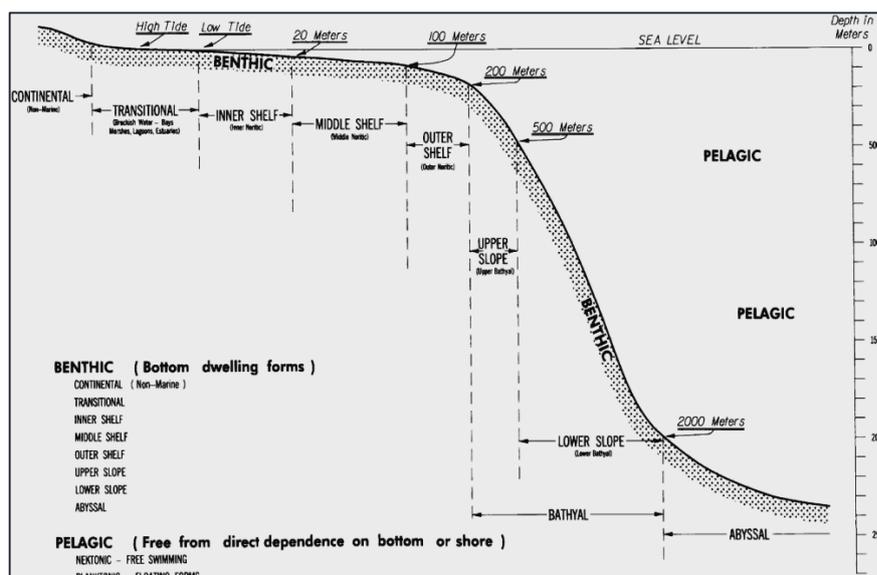


Fig.4 Classification of bathymetry (Tipsword et. al,1966).

Table 1. Pollen quantity

Sample code	Depth (cm)	Pollen (grains)
MR-1	0	254
MR-2	20	232
MR-3	40	126
MR-4	60	256
MR-5	80	180
MR-6	100	217
MR-7	120	52
MR-8	140	52
MR-9	160	52
MR-10	180	70
MR-11	200	30

The data illustrate that there were a supplied of sediment from the mountains, surrounding the upstream area, besides from the lowland and the environment around the river mouth. The role of Mahakam River as an agent to supply pollen from upland to downstream area. Pollen of Montane Forest Zone which found consist of *Altingia exelsa*, *Arenga pinnata*, *Celtis sp*, *Dacrycarpus imbricatus*, *Engelhardtia sp*, *Erica sp*, *Ilex sp*, *Phyllocladus hypophyllus*, *Pinnus sp*, *Podocarpus neriifolius*, *Quercus laurifolia*, *Taxodium sp* and *Vaccinium sp*.

Pollen of *Altingia exelsa*, *Arenga pinnata* and *Celtis sp* produced by vegetation of Submontane Forest Zone that grows an altitude 1000- 1500 m above sea level. *Dacrycarpus imbricatus*, *Podocarpus neriifolius*, *Quercus laurifolia*, *Engelhardtia sp* derived from Lower Montane Forest zone which occupies an area at an altitude of 1400-1800 m above sea level. Specifically, *Vaccinium sp* and *Erica sp* both are a type of pollen from the Upper Montane Forest that occupies an area at an altitude of 2400-3000 meters above sea level (Whitmore, 1975; Stuijts, 1933). Vegetation in the downstream area consists

of Lowland Forest, Mixed Forest, Swamp Forest and mangrove forests, and in the upstream area, there are Montane Forests.

Based on the quantity of pollen can be known that the pollen from the vegetation in the downstream area is the most common. Generally, there were mixed pollens which produced by mangrove, swamps, vegetation, lowlands and mountain vegetation (Fig.5) Pollen from lowland forest more various than from upland. The species that commonly found are *Eugeissona insignis*, *Dipterocarpus sp.* and *Cocos nucifera*. *Sonneratia alba* is the most mangrove pollen, while *Nypa fruit cans* and *Oncosperma tigillarum* are common pollen that comes from the delta plain. Based on vegetation zone of Mahakam Delta, mangrove pollen which produced by mangrove plant came from mud flat area, that laid in the distal part of lower delta plain. The existence of mangrove pollen in the mouth of a river is indicated that there was a mobilisation of pollen from distally lower delta plain to the mouth of the river (Fig. 8).

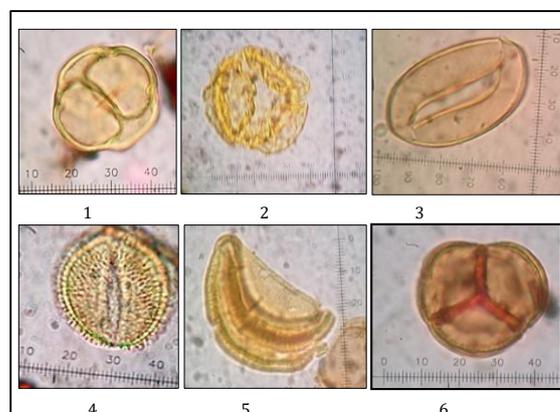


Fig. 5. *Erica sp* (1), *Dacrycarpus imbricatus* (2), *Cocos nucifera*(3), *Oncosperma tigillarum* (4), *Eugessona insignis*(5), *Vaccinium sp* (6). Microscope magnification 1000x).

4. Foraminifera analysis

Small benthic foraminiferas were found in 8 (eight) sediment samples of 11 sediment samples from river mouth Mahakam. Based on foraminifera analysis there are 13 species and 56 specimens. The **highest amount of foraminifer's specimen is 19 specimen**, found in MR-9 sample with 160 cm depth and the **highest amount of foraminifer's species is 7 species**, found in MR-11 sample with 200 cm depth. Fig. 7 shows that the amount of foraminifera increased toward deeper core (Table 2).

Table 2. Quantity of foraminifera

Sample code	Depth (cm)	Species	Specimen
MR-1	0	2	4
MR-2	20	2	2
MR-3	40	0	0
MR-4	60	0	0
MR-5	80	0	0
MR-6	100	2	2
MR-7	120	3	8
MR-8	140	3	3
MR-9	160	6	19
MR-10	180	2	3
MR-11	200	7	15
Total			56

Discover of small benthic foraminifera in the river mouth area are evidence of the energy came from

sea direction. Tidal wave have a role to encourage the sediment from the sea towards the downstream of Mahakam river. (Fig.6)

The chart shows the quantity of foraminifera in the sand sediment is a significant differ from silt sediment. The quantity of Foraminifera from sand more common than from silt sediment. Inversely condition with mud sediments that showing the quantity of pollen is very high (Fig.7). There are no benthic foraminifera in 40 cm-80 cm depth. Lack of benthic foraminifera in those interval shows that the source sediment from terrestrial. This condition is significantly different from sand sediment in 120 cm-200 cm depth which is small benthic foraminifera is more common. It means that in deeper core the source sediment not only came from terrestrial but also came from marine (Fig 8).

The species of small benthic foraminifera in all sample sediments include shallow species such as *Reusoolina stellula* and *Stictogongylus vandiemenensis*, and deep species such as *Uvigerina bradyana*. Those foraminifera assemblages are evidence of sediment marine came from shallow sea and deep sea.

The presence of benthic foraminifera in the river mouth sediment, possibly related to the transgressive phase in the modern delta area. [Salahuddin and Lambiase \(2013\)](#) found benthic foraminifera in the Nypa swamp area which located on the delta plains, they said that the sediment of modern delta shows the transgression product.

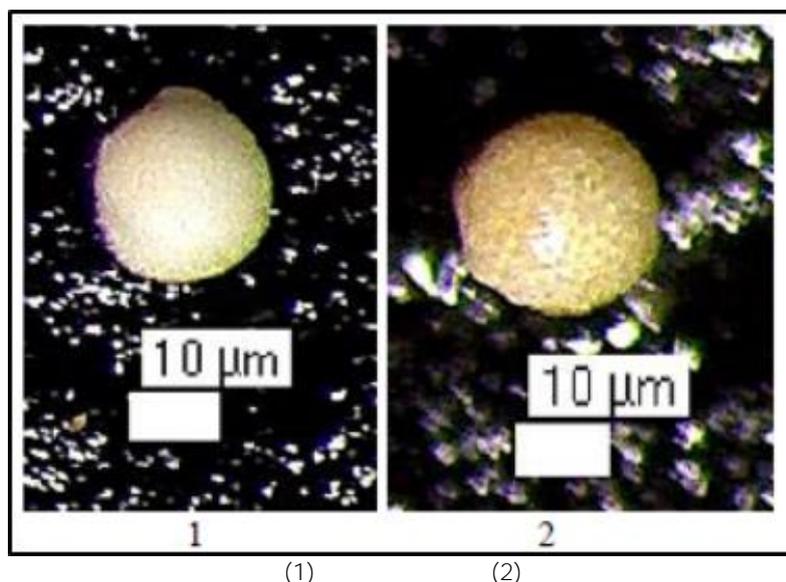


Fig.6 *Reusoolina stellula* (1), *Stictogongylus vandiemenensis* (2), (Microscope magnification 56x)

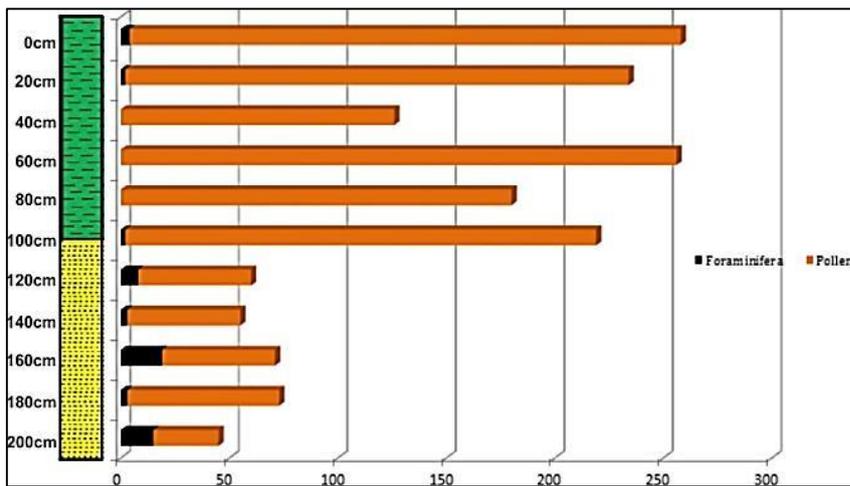


Fig 7. Quantity of pollen (grains) and foraminifera (specimen)

■ = mud ■ = sand

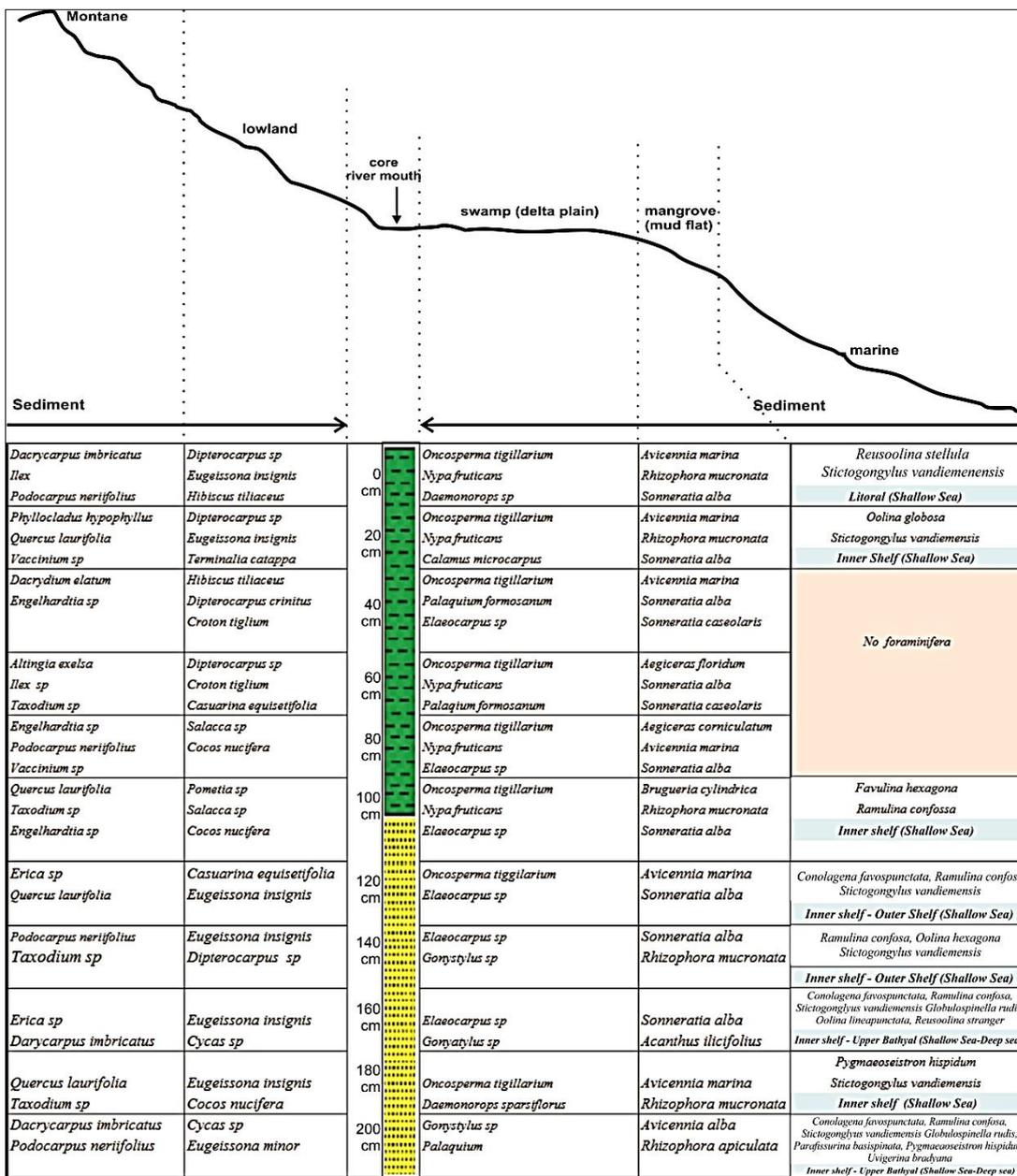


Fig. 8. Illustration of Source of sediment which filled mouth of Mahakam River based on origin of Pollen and foraminifera

5. Conclusions

The sources of sediment that fills the mouth of the Mahakam River dominated by terrestrial sediment and only a small portion of the sediment from marine. About 77, 23% samples who have observed, indicated that sediment supply from terrestrial and marine, and 27.27% samples the sediment supply only from terrestrial. The highest presence of foraminifera only 25 %, contrary to its pollen reaches 75% is the lowest presence of total pollen-foraminifera in the 200 cm depth. After that, the presence of foraminifera decrease and reaches minimum in 80-40 cm intervals by 0% so in the same intervals presence of pollen 100%

While the sources of terrestrial sediment include from the delta and surrounding areas, lowlands and highlands. Sediment from the ocean, covers shallow sea and deep sea.

There were no benthic foraminifera at the interval 40 cm-80 cm depth it indicates that the source of sediment just comes from the mainland. The differences in the depth of sediment source that fills the mouth of the river indicate the strength of tidal waves was triggered by a wave of Makassar Strait also vary in the strength.

Acknowledgements

We are particularly grateful for the assistance given by Maria who help us in processing samples.

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