Identification of Suspended Sediment Concentration

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Identification of Suspended Sediment Concentration in Stream Network

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Abstract. Two series of suspended sediment concentration measurement within a stream network carried out during the dry and rainy season are presented in this paper. Information on suspended sediment concentration obtained from measurement are plotted on the map of stream network to allow a comparison between designated rivers. The finding suggests that concentration of suspended sediment do not coincide with stream order. First stream order of both series of measurement have a lower concentration level of suspended sediment than that of the second and the third order respectively. A noticeable difference experienced by the fourth order river. Quite unexpectedly it has a lower suspended sediment concentration than the second and the third order rivers within the stream network. These features are found both in dry and rainy season measurement. Although there is a complexity in suspended sediment concentration transported by rivers of different order, the resulting map is very useful to be adopted as a main consideration in determining suitable approach and priority works in dealing with potential erosion and sedimentation of high degrading basin both using engineering and non engineering approaches.

Introduction

Most of the river basins in Lombok Island experience a rapid change in land use due to a substantial conversion of the basin into tourist resorts and new residential areas. It is also observed in recent times that the transformation of virgin forest and grassland into cropland are becoming increasingly disturbing especially in the densely populated areas. Further removal of forest for agriculture and constructions contribute to the increase in the deposition of the underlying soil to be eroded. Detachment of soil eventually reaches the stream network and the rate of erosion and sedimentation in river becomes greatly accelerated. The decrease in the ability of the catchment area to avoid surface erosion lead to the increase in the vulnerability of the downstream area. This is particularly important in river training and should be controlled both by engineering and non-engineering techniques. The latter is conducted through conservation project to allow rivers to be maintained in such a way that the waterflow is sufficiently good both in quantity and quality. One of the urgent activities is to identify the present state of the river related to the suspended sediment concentration and to plot the information into basin maps [1]. The map will be used as the basic consideration in determining the type of activities and the level of urgency in dealing with rivers network within a particular basin.

The aim of this study was to observe the concentration level of suspended sediment within stream network and to plot the results into a map. River Jangkok has been selected due to its important role in Lombok Island which is one of National Strategic River Basin in Indonesia. The map contain information on the characteristic of the rivers and the concentration of suspended sediment transported in main river and its tributaries. It is expected that the present concentration level can be compared in the future measurement so that design of reclamation works within a stream network can be determined. The priority of the reclamation works is arranged where the river with higher concentration level of suspended sediment is on top of the list followed by river with lower level. In a condition that the available budget from government is insufficient, the conservation works is concentrated on the river with highest level of concentration, i.e. the works for the basin are carried out in stages.

Literature Review

Natural rivers are rarely free of sediment and it is obvious that each reach of a single river has its own sedimentological character. Predictions of sedimentation rate can only be done accurately based on sufficient understanding of the physical process through an extensive field measurement. Different procedures have been developed for sampling and analyzing material. Traditionally this has been directly measured by sampling small incremental river widths and depths using some type of equipment. This technique provides material samples for sieving analysis. Standards for sieving mineral aggregates samples have been established by several organizations (e.g. ASTM, ISO, BS). When the grain size distribution of sediment are required, other techniques such as areal, grid, or transect sampling and volumetric sampling are used [2,3]. These surface sampling techniques produce samples that are unique and, thus, results from the different sampling methods are not directly comparable [4].

A meaningful sample must be drawn from a homogeneous body of sediment. Temporal elements involved in sampling are the sampling time and its interval that elapses between consecutive samples as well as the period of sampling [5]. Some studies, e.g. Hubbel [6] found that errors can be great in cross-sections where the lateral distribution of mean transport rates is extremely non-uniform, whereas errors are relatively moderate where high and low mean transport rates occupy similar proportions of the width or where most of the width has transport rates higher than the mean rate for the entire cross-section.

Measurement of sediment transport in river is considered to have some complexity with less attention from authority particularly in developing countries. This low priority is contradict to the fact that the magnitude and intensity of transported sediment in river are beneficial in indicating the level of basin degradation [1,7]. In rivers with reservoir, measurement are focused on sediment deposited in the reservoir using special equipment such as echosounder. This method is a negative approach as it is very effective in obtaining information on the deposited sediment only and ignoring the prevention of the deposit. It is more difficult for reservoir with more than one river as no information on the level of sediment contribution for each river [8]. It is therefore, measurement should be carried out in all rivers connected to the reservoir to discover the main contributor to the reservoir sedimentation. Based on the finding, conservation works can be concentrated on the high degraded sub basin through activities such as reforestation and possibly the construction of check dam in the uppercourse of the river. The reservoir sedimentation rate is expected to decrease in long term and the huge amout of the budget for construction works can be considerably justified as the result of an increased in the lifetime of the reservoir.

Many assume that the sediment transport behaviour of the nearby rivers is identical and being considered to have similar pattern. This assumption is probably incorrect considering the fact that human intervention as another factor in accelerated erosion can have different conservation practices in the adjacent river and sub basin. The quantity of sediment transported downstream in alluvial rivers is a function of supply and river transporting capacity. The sediment supply depends on the surface erosion and the erosion from river bank and bed scouring. The transporting capacity is a function of sediment size, flow discharge, and the geometry of the stream. The equilibrium condition can be expected when transporting capacity equal to sediment supply. In reality, the equilibrium state is difficult to achieve because of the significant variation in the riverbed stability. In many rivers the apparent stability of the bed can vary significantly even during floods of similar magnitude [9]. The characteristic of riverbed formed by high variability in sediment size also makes the equilibrium state is difficult to achieve. In term of suspended load transport of sediment mixtures, the analysis is more complex because of the influences of grains exposure to the bed load transport and therefore the concentration close to the bed [10]. The interference between grain sizes in the process of entrainment and suspended load movement also affecting the exponent in the sediment distribution equation [10].

Lack of awareness and low attention level are the main reason to the limited measurement where the data from one river reach is considered to represent the whole basin. This theory should be corrected as each river and its tributaries has its own sediment transported rate regardless of the geographically adjacent location. Saadi [8] investigated three nearby rivers in the upstream part of a dam and found that three rivers have suspended sediment transport rates ranging from two to fivefold. The contribution of each river to the reservoir sedimentation is then vary accordingly.The finding suggests that the measurement of suspended sediment transportation rates in rivers within elementary basin is undoubtedly rellevant and greatly importance. Furthermore, the mistakes from the generalized calculation can be avoided and the priority of reclamation works can be determined.

Methodology

Stream network selected for this reasearch is in the uppercourse of River Jangkok (Figure 1). The first series of measurement were carried out during the dry season and the second series were conducted during the rainy season. All measurement points were selected to represent the best sampling sites. Those points were marked and positioned using an instrument of Global Positioning System to allow repeated measurements to be taken at the same location.

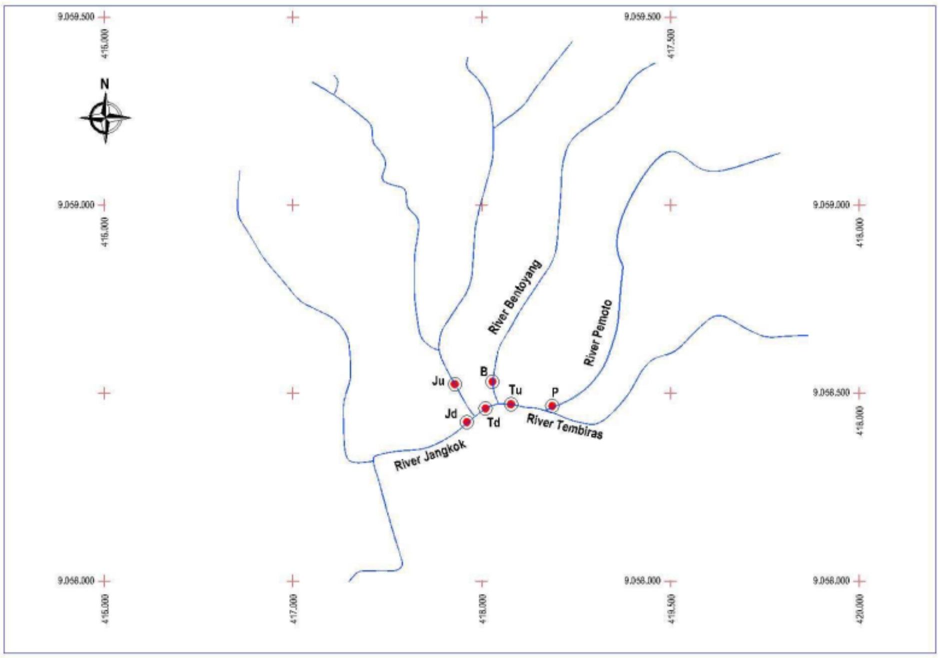

Fig. 1. Stream network and measurement points in the uppercourse of River Jangkok

The works in this research involving measurement of the area of the river and flow velocity in order to obtain the discharge. Velocity was measured at different depth and different location depending on water depth and the width of the river. The equipment used for this purpose was flow meter wading set Valeport Model 001. Suspended sediment was collected at selected time interval by using cylindrical sediment sampler. Subject to its proportional dimension this type of sampler can give more accurate measurement with trap efficiency between 0.8-1.2 for moderate flow [11]. Suspended sediment sampler was positioned according to the requirement stated in Indonesia National Standard SNI 3414 : 2008 [12] and also at different point in lateral direction within the same cross section. This allowed a sufficient data to be taken from representative location. The measurement were conducted in a way that the movement of sediment was not affected by the operation of the equipment. Repetitive sampling were carried out when necessary. It was also considered that more reliable results can be obtained by long sampling times than that of short one.

Samples in the container were labeled based on the location and time of measurement. The weights of samples were obtained by sieving analysis after the samples were dried in an oven. All samples were carefully restored to allow further analysis if the mistakes occurred during the process of examination.

Results and Discussion

The concentration of suspended sediment is believed to be approximately constant over the cross section. The samples were taken at points which have been found to be representative for each river after each sub basin is progressively numbered in downstream direction. The stream order express the hierarchical relationship between stream segment. It is started from the farthest point of the water course. Stream order as defined by Strahler [13] has been applied for the purpose of this research where a stream segment with no tributaries is designated a first order. A second order is formed by the joining of two first order segment and continue to the higher order which is formed by the joining of two or more lower order segments. Based on stream network in Figure 1, tributaries in the upper course of River Jangkok have been identified as the river with first to fourth order. River Pemoto (P) and River Bentoyang (B) are the first order rivers. River Tembiras Upstream (Tu) is the second order, whilst both River Tembiras Downstream (Td) and River Jangkok Upstream (Ju) are the third order rivers. The highest order investigated in this research is River Jangkok Downstream (Jd) which is the fourth order river.

In general the concentration of suspended sediment in the stream network of River Jangkok measured during the dry season indicates reasonable results. As seen in Figure 2 the lower order of river such as the first order is expected to have lower concentration. This is reasonably accepted as the sources of sediment are mainly from smaller unit of sub basin with a single and small stream as the conveyance. Sediment in rivers includes particles previously carried downstream as well as material contributed directly from river bank and from valley-side slopes.

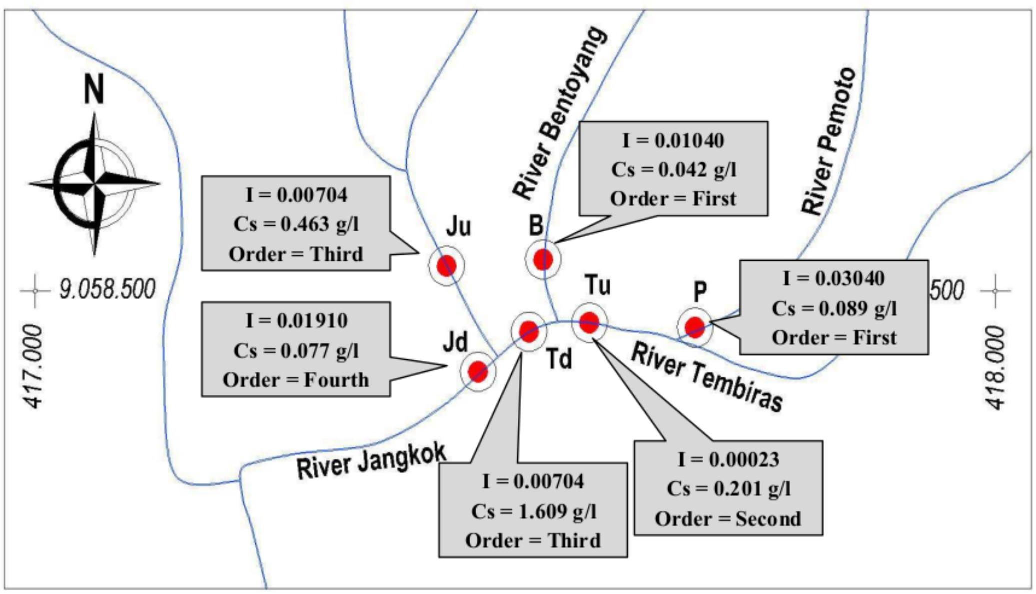

Fig. 2. Suspended sediment concentration in stream network of River Jangkok during the dry season

The concentration of suspended sediment experienced by River Pemoto (P) and River Bentoyang (B) clearly support this. Both have 0.089 g/l and 0.042 g/l of suspended sediment concentration for every cubic metre per second of flow discharge. The concentration increase at the higher order shown by River Tembiras Upstream (Tu). This second order river has 0.201 g/l of suspended sediment. The concentration continue to increase in the third order river where River Tembiras Downstream (Td) and River Jangkok Upstream (Ju) have 1.609 g/l and 0.463 g/l of suspended sediment respectively.

Inconsistency is found in River Jangkok Downstream (Jd). The fourth order river should contain suspended sediment at higher concentration rate than the others. The experience of River Jangkok Upstream (Ju) suggests that sediment transport behaviour of the nearby rivers is not identical. Although the quantity of sediment transported downstream is a function of supply it does not necessarily coincide with the rivers within the stream network. The lower transporting capacity of River Jangkok Upstream (Ju) is thought to be influenced by geometry of the river reach where the samples were taken. Normally found in the majority of stream network, discharge increases downstream as tributaries add more runoff progressively to the main river. In some cases losses through epavoration and seepage may lead to a downstream decrease in discharge but in the short distance between river reaches this seems unlikely. Backwater curve caused by the confluence may have some influence in altering the suspended sediment to flow downstream. The plot in Figure 2 describe that River Tembiras Downstream (Td) has the potency to transport suspended sediment at higher concentration than the other rivers within the stream network of River Jangkok.

A comparison between the dry season and the rainy season measurement suggests that all rivers transported more suspended sediment concentration during the second measurement (see Figure 3). The increased are ranging from small to a significant level. This is understandable as the higher discharges during the rainy season are more capable of transporting suspended sediment. Subsequent rainfalls to some extent are also believed to have a contribution in an increase in soil loss from the basin.

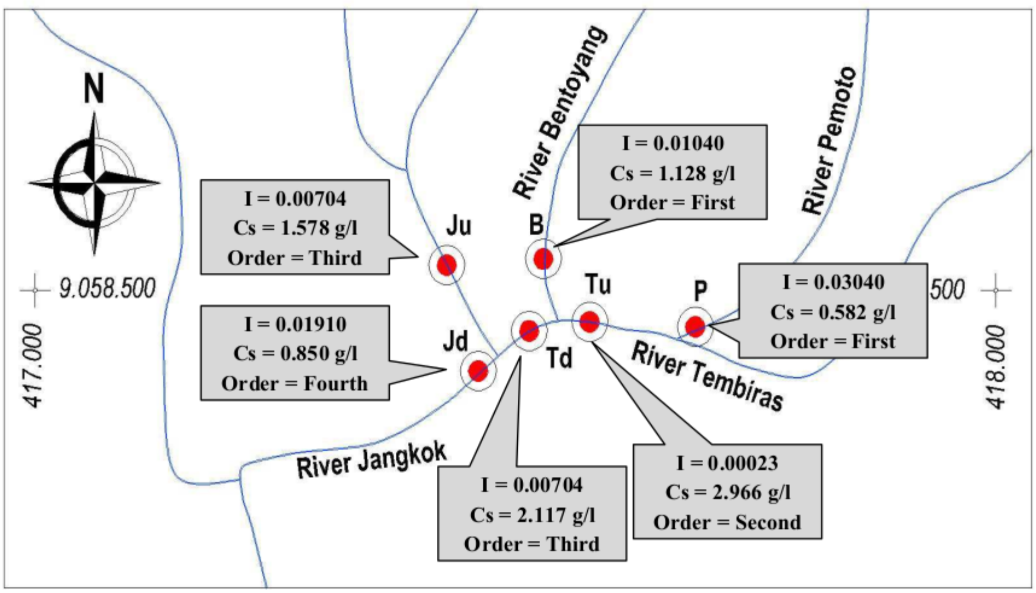

Fig. 3. Suspended sediment concentration in stream network of River Jangkok during the rainy season

As shown in Figure 3 a slightly different finding is observed from the second series of measurement taken during the rainy season. The first order rivers of River Pemoto (B) and River Bentoyang (B) have lower concentration of suspended sediment compare to second and third order rivers, i.e. River Tembiras Upstream (Tu), River Tembiras Downstream (Td) and River Jangkok Upstream (Ju) respectively. This is similar to the finding obtained from the first series of measurement. However, another important finding correspond to the first series of measurement is the lesser concentration experienced by River Jangkok Downstream (J2). Although there is an increase more than tenfold between dry season and rainy season concentration, River Jangkok Downstream (Jd) has smaller level of suspended sediment concentration than four rivers with lower order. Only River Pemoto (P) contains suspended sediment concentration at a lower level of 0.582 g/l in comparison to 0.850 g/l of River Jangkok Downstream (Jd).

Contrary to the finding obtained from the first series of measurement, River Tembiras Upstream (Tu) carried suspended sediment concentration more than River Tembiras Downstream (Td) during the second measurement. In rainy season River Tembiras Upstream (Tu) contained 2.966 g/l of suspended sediment whereas River Tembiras Downstream (Td) carried 2.117 g/l. Comparison between the two series of measurement indicate an increase in concentration between dry and rainy season but with different level for both river reaches. Very significant increase of more than fourteenfold experienced by River Tembiras Upstream (Tu) whilst a small increase of less than twofold experienced by River Tembiras Downstream (Td). These findings are somewhat difficult to explain. Looking at the geometry of the reach and surrounding area of River Tembiras Downstream (Td), human intervention is probably another contributing factor. It is noticeable that the riverbank on the left hand side of River Tembiras has been transformed into a place of agriculture practices. However the argument is insufficient to support the occurrence of the phenomenon. In predicting the rate of erosion on a particular riverbank slope under a given set of conditions, it is extremely difficult to quantify the resistance of riverbank materials to entrainment and transport as well as the difficulty in determining the potential of riverbank processes to cause erosion. Under different flow conditions with a clear seasonal variation between dry and wet season, river flow tend to vary fairly systematically throughout the year. This underlines the problem in predicting the concentration rate of suspended sediment in natural rivers. Further investigation is necessary to find out if periodical measurement representing different season have a similar tendency. Information on the average annual variations in discharge and observation to the river geometry and other related factors are considerably important in order to explain the phenomenon.

Summary

The complexity of suspended sediment behavior in a stream network has been reflected in this research. There is a similar trend between dry season and rainy season measurement but at the same ground inconsistencies exist between the stream orders. Dry season measurement in which first order rivers experienced lower concentration of suspended sediment than the second order are correspond to rainy season measurement. The similarity between the two series of measurement is also found in the decreased of suspended sediment concentration experienced by the fourth order river. The similarity to some extent together with the inconsistencies in the finding between different order, most notably between the second and the third order river raise the importance of increasing the number of measurement in different season with various discharges. There are many factors other than river behavior and river geometry should be addressed if the more acceptable results are to be expected. This includes the observation of human intervention through the agriculture practices and the use of riverbank and the basin for other purposes.

Observation to the suspended sediment concentration is the initial step to determine the priority in maintaining the level of service of the river. Information on the map gives indication to the level of attention to each river within the stream network, where particular attention should be given to the river with high concentration level of suspended sediment.

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References

[1] Y. Saadi, A. Suroso, and I.B.G. Putra, The mapping of river state order based on sediment transportation rates, Final Report of National Strategic Research Grant, Research Centre of Mataram University, Mataram, 2012.

[2] M.A. Church, D.G. McLean, and J.F. Wolcott, River bed gravels: sampling and analysis, in: Sediment Transport in Gravel Bed Rivers, C.R. Thorne, J.C. Bathurst, and R.D. Hey (Eds.), John Wiley and Son, New York, 1987, pp. 43-88.

[3] P. Diplas, and A.J. Sutherland, Sampling techniques for gravel size sediments, Proc. American Society of Civil Engineers., Journal of Hydraulic Engineering, 114 (5), 1988, pp. 484-501.

[4] P. Diplas, and J.B. Fripp, Properties of Various Sediment Sampling Procedures, Journal of Hydraulic Engineering, 118 (7), 1992, pp. 955-969.

[5] B. Gomez, Bedload transport, Earth Science Review, 31 (2), 1991, pp. 89-132.

[6] D.W. Hubbell, Bed load sampling and analysis, in: Sediment Transport in Gravel Bed Rivers, C.R. Thorne, J.C. Bathurst, and R.D. Hey (Eds.), John Wiley and Son, New York, 1987, pp. 89-118.

[7] Y. Saadi, H. Saidah, and L.D.B. Irawan, Overview of erosion index and erosion hazard classification in River Tanggek Sub Basin, Proceeding of 4th National Conference of Civil Engineering, Bali, (2010), pp. 467-476.

[8] Y. Saadi, River sediment-discharge rating curve for predicting reservoir sedimentation (A case study of 3 rivers of Batujai Dam), Proceeding of National Conference on Sustainable Infrastructure Development, Bali, (2007), pp. 56-70.

[9] Y. Saadi, and S.J. Tait, The influence of time varying antecedent flows on the stability of mixed grain size sediment deposits, Proceeding of 3rd International Symposium on Environmental Hydraulics, Tempe, Arizona-USA, (2001), Manuscript 00124.

[10] B.R. Samaga, K.G. Ranga Raju, and R.J. Garde, Suspended load transport of sediment mixtures, Journal of Hydraulic Engineering, 112, (11), 1986, pp. 1019-1035.

[11] L.C. van Rijn, Manual Sediment Transport Measurements, Report S304, Delft Hydraulics, The Netherland, 2006.

[12] National Standardisation Board, Guideline of Sediment Sampling Measurement with Depth Integration Method Based on the Discharge Division, SNI 3414 : 2008.

[13] A.N. Strahler, Quantitative geomorphology of drainage basins and channel networks, in: Handbook of Applied Hydrology, V.T. Chow (Eds.), McGraw-Hill, New York, 1964, Section 4-II.

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