International Journal of Advance Research in Science and Engineering
Volume No.08, Issue No.05, May 2019
www.ijarse.com
IJARSE
ISSN: 2319-8354

Laboratory Techniques for Investigation of Geo-Environmental status for Assessing Pollution from In-stream River Bed Sand Mining

Sabbir Kumar Jamatia[1], Shubhankar Debbarma[2]

[1,2]*Civil Engineering Department, Tripura Institute of TechnologyNarsingarh, India*

ABSTRACT

The present paper is aimed to draw clear picture on laboratory technique for geo-environmental investigation mainly for assessing pollution from the in-stream River Bed sand mining. There are various environmental components which are needs to be analyzed for evaluating pollution from in-stream river bed sand mining. The present papers is committed to capture majorities of the environmental dimensions related sand mining to enable various stack holders to acquire good understanding about the methods of laboratory techniques. The laboratory techniques include air, water and noise apart from sediment transport load estimation. The method of air quality monitoring is also incorporated apart from noise aimed to analyze the deterioration level in and around the sand mining area. There are 11 important water parameters considered in determination of water quality in terms of pollution. The method and materials as elaborated in the paper is committed to redress problems related to geo-environmental investigation. It is also an emphasize towards monitoring and investigation on geo-environmental issue that obvious to provide results/data on various environmental qualities including profile change and sediment transport capacity of the river to evaluate the long-term environmental effects of the mining activities both upstream and downstream of sand extraction sites.

Keywords: Investigation, Geo-Environment, In-stream sand mining, Extraction, Geo-morphology, Technique.

1. INTRODUCTION

Sand is considered as an important mineral resource [Saviour, M. N., 2012]. Excessive removal of river sand from river bed may significantly distort the natural equilibrium of a stream channel. Large scale mining of river sand several folds has led to irreparable damages to the land, water, biotic and social/human environments related to river systems. The magnitude of the impact basically depends on the magnitudes of the extraction relative to bed load sediment supply and transport through the reach. The problem is very acute where the rivers are small with limited river bed resources. By removing sediment from the active channel bed, in-stream sand mining interrupt the continuity of sediment transport through the river system, disrupting the sediment mass balance in the river downstream and inducing channel adjustments extending considerable distances beyond the extraction site itself. [Kondolf et al., 2001]. The indiscriminate sand mining from the rivers is detrimental to environment. It effects physical, biological and social environments [Ghose, 1989]. Moreover, in-stream sand mining may continue for long period may effects upstream or downstream geomorphic during high flows [Collins, B. D. and Dunne, T., 1990]. Sand mining disturbs the equilibrium of a river channel because it intercepts material load moving within a dynamic system and triggers an initial morphological. Habitat alteration is also inevitable when morphological adjustments take place. The extent of these effects depends upon the type and scale of sand extraction, the channel's resistance to erosion, and watershed differences in hydrology and sediment transport. There is no exemption in the rivers of Tripura also. The increasing consumption of river sand significantly effects the 10 (ten) major rivers by sand mining. The ten major rivers such as Burima, Gomati, Khowai, Howrah, Longai, Dhalai, Muhuri, Feni, Juri, Manu are now under the threat of sand extractors. Though, the major ten rivers of Tripura are playing a unique role to meet up the drinking water requirement in most of the cities/towns so far the Tripura State is concerned. Unfortunately, in the vast majority of the rivers/water bodies are getting polluted in urban areas and becoming unsuitable for use of downstream settlement due to human interference. The rivers of Tripura are generally ephemeral in nature and their flow is directly related to the rainfall. All the major rivers are originated from hill ranges. Annual average flow of ten major Rivers is estimated to 793 million cubic meters. Collectively basin area of ten major rivers and other minor streams covers nearly 10,500 sq. km. The major rivers and their tributaries, narrow streams originated from elevated topography, which are passing through the area having loamy soil. During monsoon season, the flow and the velocity of water in all these ephemeral rivers increases and induces erosion along two banks of the river. During rain, surface run off from elevated topography carries huge amount of sand and other coarse particles to the river bed. Sand carried by surface runoff during rainy season gets deposited on the river bank adjacent to river channel. The available sand deposit in river/stream bank is meeting the demand of coarse aggregate in construction sectors. However, instead of use of naturally deposit river sand, in-stream sand mining is being carried out to extract the river sand. Such an in-stream sand mining from the river beds is causing serious threat to the flow of the river, forests upon river bank and most seriously to the environment of many areas of Tripura.

2. OBJECTIVES

The objective of the paper is intended to present method of geo-environmental investigation for assessing pollution from river bed in-stream sand mining. It is also an attempt towards preparation of a suitable mitigation plan for addressing pollution so that sustainable goal of sand mining can be achieved.

3. METHODS AND MATERIALS

The laboratory investigation techniques will capture various dimensions of geo-environmental status viz. ambient air quality, noise quality and water quality of a stream/river where extraction of sand is carried out from the river bed. The estimation of sediment transport load is intended to draw a picture of geomorphic alteration of a stream/river. There are various laboratory investigation methods available for assessing pollution from river bed in-stream sand mining. The presented laboratory technique is one of the techniques among others for investigation of geo-environmental status for assessing pollution from in-stream river bed sand mining. The details for capturing various dimensions of air, water, noise and sediment transport load are elaborated below:

3.1Air Environment:

Ambient air quality monitoring is necessary for investigating air environment. For this purpose, Respirable Dust Sampler (Envirotech APM 460 XNL) with gaseous pollutant attachment (Envirotech APM 411 TE) is commonly used. The scope of air monitoring is to capture existing ambient air quality and also to analyze trend of depletion of air quality at the cluster of sand mining and its adjacent area. The predominant wind direction is given importance in selection of the ambient air quality sampling stations in the study. The dispersion of gaseous and particulate emissions depends on the predominant wind directions and affects the receptors located at downwind. Monitoring of PM_{10}, SO_2 and NO_2 shall be carried out at a flow rate of 1.0- 1.04 m^3/min for 24 hours using pre-weighed cellulose filters, Whatman (EPM-2000) of 20 x 25 cm in size.

3.1.1. PM_{10} Measurement:

The filter papers contained with respirable fraction of fine dust re-weighed after sampling. In order to determine the mass of the particles, subtract the initial weight of filter paper from re-weighed filter papers that contained with respirable fraction of fine dust after sampling. Calculate the PM10 concentration with the following equation:

$$PM_{10} \text{ concentration in } \mu g/m^3 = [\text{Weight of dust x } 10^6]/ \text{ Volume of air}$$

Where, Volume of air = Actual flow x time (minute)

Actual flow = [Initial flow + Final flow]/ 2

3.1.2. SO_2 and NO_2 Measurement:

The SO_2 and NO_2 samples are taken for every 8 hours. Freshly prepared the Potassium Tetrachloromercurate solution (TCM) was used as absorbing solution to absorb SO_2 in the impinger at the time of sampling. On the other hand, nitrogen dioxide (NO_2) is absorbed in absorbing solution prepared by dissolving sodium hydroxide in distilled water and adding sodium arsenide. The sampling instrument is being fixed at the height of 3 m above the ground level. Representative air samples of SO_2 & NO_2 are analyzed using Spectrophotometer (model Spectronic 21D) determination of absorbance.

3.1.3. Determination of Calibration Factor:

Determination of calibration curve is done using regression analysis by the method of least squares. Calibration factor of both gaseous pollutants are calculated separately by determining the slope of the line of best fit. The formula as used in determination of best fit and regression analysis are presented below:

We know that a linear equation is Y = A X + B [where, X & Y are variables]

Consider,

$X_1, X_2, X_3 \ldots X_n$ are the concentration of various standard samples.

$Y_1, Y_2, Y_3 \ldots Y_n$ are the Absorbance Reading as read in spectrophotometer.

Calculate, the values of $\sum X$, $\sum Y$, $\sum XY$, $\sum X^2$, $\sum Y^2$ by statistical method.

Calculate,

$$A = [N.\sum XY - \sum X.\sum Y] / [N.\sum X^2 - (\sum X)^2]$$

$$B = [\sum Y.\sum X^2 - \sum X.\sum XY] / [N.\sum X^2 - (\sum X)^2]$$

Generate standard equation of best of curve fit.

The generalized standard equation of best of curve, suppose, $y = ax + b$

Analyze Regression, $R = \sum XY / [\sqrt{\sum X^2}.\sqrt{\sum Y^2}]$

R value in between 0.99 to 1.01 or 1 ± 0.01 is acceptable.

Calculate the values of y and x by the principle of Least Square

The value of x/y represents the Calibration Factor (CF).

So far calculated CF value for individual pollutant is used in calculation pollutant concentration. The Calibration Factors for both pollutants as generated are being used to calculate the concentration of SO_2 & NO_2.

3.1.4. SO_2 Calculation:

Compute the concentration of SO_2 in microgram per cubic metre in the samples as follow;

Concentration SO_2 in $\mu g/m^3 = (A-A_0) \times 10^3 \times CF \times D/V$

Where,

A= Sample Absorbance

A_0=Reagent Blank Absorbance

CF= Calibration Factor

10^3= Conversion of litre to cubic metre

D= Dilution Factor

V= Volume of Air

3.1.5. NO_2 Calculation:

Similarly, we may compute concentration of NO_2 in microgram per cubic metre in the samples by the following -

Concentration SO_2 in $\mu g/m^3 = (A_s-A_b) \times CF \times Vs / [Va \times Vt \times 0.082]$

Where, A_s = Sample Absorbance

A_b = Reagent Blank Absorbance

CF = Calibration Factor

Va = Volume of Air in cubic metre

Vt = Volume of aliquot taken for analysis, ml

Vs = Volume of sample, ml

The analytical values of PM_{10}, SO_2 & NO_2 are compared with the CPCB standard to find out deterioration in local air quality if any. The levels of deterioration of air quality are expressed in terms of low, moderate, high and critical by calculating an excedence factor (EF). The excedence factor is the ratio of annual mean concentration with that of respective standard. An EF value more than 1.5 indicates critical pollution. Simultaneously, high pollution means the when EF is between 1-1.5, the EF ranges between 0.5-1 is called moderate pollution and EF values less than 0.5 is expressed as low pollution.

3.2. Noise Environment

The noise pollution in and around the river sand mining area is mainly from the vehicular movement. The different categories of area such as residential, commercial, industrial and silence zones need to be identified before monitoring. Ambient noise monitoring has to be conducted using Sound Level Meter. Sound Pressure Level (SPL) measurements in dB (A) are need to be recorded for both day and night time. The day time noise monitoring will be during 6 a.m. to 10 p.m. Similarly, night time noise data will be collected during 10 p.m. to 6 a.m. in compliance with the CPCB guidelines. Equivalent noise levels in the form of L_{eq} day and L_{eq} night were computed using the formula.

$L_{eq} = 10 \log (\sum t_i \times 10^{Li/10})$

Where, L_{eq}= Equivalent sound pressure level,

L_i = The noise level of any i^{th} sample,

n=Total number of sound samples,

t_i = Time duration of i^{th} sample expressed as fraction of total sample time.

The results obtained are need to be compared with the standard specified in Schedule III of Noise Pollution (Regulation and Control) Rules, 2000.

3.3. Water Environment

To quantify the trend of deterioration of water quality various physical and chemical parameters are considered as important tools for study of pollution level for surface water. An inventory is also necessary in this regard to identify the polluting sources. Quantification and characterisation are also taken into the consideration for evaluation of water quality. Assessment of water pollution is to be made based on the analytical results with respect to physio-chemical characteristics. The methodology for estimation of various water parameters are presented below:

3.3.1. Dissolved Oxygen:

Dissolved Oxygen in the water sample can be estimated either by iodometric method or azide modification method. In the present study, azide modification followed by titrimetric procedures is used in determination of DO. Standard sodium thiosulphate solution is used as titrating agent. To the sample collected in a 250 ml bottle, add 1 ml of Manganous sulphate solution, azide solution and 1 ml concentrated sulphuric acid. Add 2-3 drops of starch indicator in 200 ml sample prior to titration.

$$2\,MnSO_4(s) + O_2\,(aq) \longrightarrow 2MnO(OH)_2\,(s)$$

$4\ Mn(OH)_2(s) + 0_2(aq) + 2H_2O \longrightarrow 4\ Mn(OH)_3(s)$

$Mn(So4)_2 + 2\ I^-(aq) \longrightarrow Mn^{+2}(aq) + I_2(aq) + 2SO_4^{-2}(aq)$

$2S_2O_3^{-2}(aq) + I_2 \longrightarrow S_4O_6^{-2}(aq) + 2I^-(aq)$

3.3.2. Bio-chemical Oxygen Demand:

The amount of oxygen required for microbes to carry out the biological decomposition of dissolved solids or organic matter under aerobic conditions at standard temperature is known as Bio-chemical Oxygen Demand. Dilution Method test is commonly as it gives uniform results and tests while comparing various results and tests. It is used as a measure for determining the strength of sewage and also helps in finding out the amount of clear water required for successful disposal of sewage by dilution.

Calculation: BOD = [Initial DO- Final DO] x Dilution Factor

3.3.3. pH:

Measurement of pH is one of the most important and frequently used tests in water and waste water samples. pH measurement was done electrometric method using Eutech Instrument model pH-700. The sensor electrode attached with the Eutech Instrument model pH-700 is a bulb of special glass containing a fixed concentration of HCl or buffered chloride solution. Upon immersion of a new electrode in a solution the outer bulb becomes hydrated and exchanges sodium ions for hydrogen ions to build up a surface layer of hydrogen ions.

3.3.4. Turbidity:

The standard method for determination of turbidity is Nephelometric Method. This method is based on a comparison of intensity of light scattered by the sample under the defined conditions. Hanna Instrument model HI88713 Turbidity Meter is used in determination of turbidity of the water samples.

3.3.5. Conductivity:

The conductivity is a measure of the ability of an aqueous solution to carry an electric current. The ability depends on the presence of ions, on their total concentration, mobility and valence. Solutions of most organic compounds are relatively good conductors. Conversely molecules of organic compounds they do not dissociate in aqueous solution conduct a current very poorly. Mettler Toledo conductivity meter is being used in determination of conductivity of any water samples.

3.3.6. Total Dissolved Solids (TDS):

A well-mixed sample is filtered through a standard glass fibre filter and the filtrate is evaporated to dryness in weighed porcelain dish and dried to constant weight in an oven at 180^0C. The increase in dish weight over that of the empty represents the Total Dissolved Solid. Total Dissolved Solidis calculated using the following equation.

Total Dissolved Solid [mg/l] = (A-B) x 1000 / sample volume in ml.

Where, A = weight of dried residue+ dish, mg.

B= weight of dish, mg.

3.3.7. Total Suspended Solids (TSS):

Suspended solid are those solids which are remain floating in water/sewage. A well-mixed sample is filtered through a standard glass fibre filter and residue retained on the filter is dried to a constant weight in an oven at 103 to 105^{0}C. The increase in weight of the filter represents the total suspended solid. Total Suspended Solids (TSS) is calculated using the following equation.

Total Suspended Solids [mg/l] = (A-B) x 1000 / sample volume in ml.

Where, A = weight of filter + dried residue, mg.

B = weight of filter, mg.

3.3.8. Alkalinity:

Alkalinity of water is its acid neutralising capacity. It is measured by titration method. 0.02 N H_2SO_4 solutions are used as titrating agent. 1-2 drops of methyl orange is used and added in the 25 ml of sample. Colour changed from orange to reddish is an indicator.This conversion is usually computed at a pH about 10.

$$2OH^- + H_2SO_4 \longrightarrow 2H_2O + SO_4^{-2}$$

3.3.8. Chloride:

Argentometric method is commonly used for determination of Chloride. Use of 1-2 ml of potassium chromate indicator solution in the 10 ml samples indicates the end point of the silver nitrate titration of chloride.

$$Cl^- (aq) + Ag^+(aq) \longrightarrow Agcl(s) \text{ at } Ksp = 1.70\times10^{-10}$$

Where, Ksp = Constant Solubility product.

3.3.9. Nitrate:

Determination of nitrate by the method of UV spectrophotometer is found suitable. Take 50 ml clear sample and add 1 ml HCl solution and mix thoroughly. Prepare standard in the range 0-7mg/l by diluting to 50 ml for NO_3-N. Prepare intermediate mixture solution in the range 0-35 ml. Read absorbance against redistilled water set at a zero absorbance. Use a wavelength of 220 nm to obtain nitrate reading. Use a wavelength of 275nm to determine interference due to dissolved organic matter. Subtract two times the absorbance reading at 275 nm from the reading at 220 nm to obtain absorbance due to NO_3. Construct a standard curve by plotting absorbance due to NO_3 against NO_3-N concentration. Using corrected sample absorbance, obtain sample concentration directly from standard curve.

3.3.10. Chemical Oxygen Demand:

The organic matter present in the sample gets oxidised completely by $K_2Cr_2O_7$ in presence of H_2SO_4, $AgSO_4$ and $HgSO_4$ producing CO_2 and H_2O. Three COD vials with stoppers are necessary for COD estimation. Add 2.5 ml sample in two vials and take one vial for blank. Add 1.5 ml $K_2Cr_2O_7$ to each vial. Add again 3.5 ml H_2SO_4 and catalyst in same manner. Catalyst mixture samples and blanks must be placed in to COD digester at the fixed temperature of 150^{0}C. After digestion, the vials are being cooled down in room temperature. Thereafter, add few drops of ferroin indicator to each sample. Titrate it with the ferrous ammonium sulphate till the colour changes from green to reddish brown.

$$COD\ [mg/l] = [A-B] \times N \times 8 \times 10^3 / \text{volume of sample}$$

Where, A= Volume of ferrous ammonium sulphate for Blank.

B= Volume of ferrous ammonium sulphate for sample

N=Normality of ferrous ammonium sulphate.

3.4. Sediment Transport Load:

Sediment transport basically depends on the magnitudes of the extraction relative to bed load sediment supply and transport through the reach. As sediment transport is disrupting the sediment mass balance in the river downstream and disturbs the equilibrium of a river channel, therefore, estimation of sediment transport load is important parameters to assess the habitat alteration by means of morphological adjustments. The sediment transport can be estimated in the following ways:

The bed load can be estimated using Meyer-Peter and Muller Equation:-

$\Theta_B=8\ [\tau^t_*-0.047]^{3/2}$

Where, Θ_B = Bed load function

$= q_B / [\{\Upsilon s\,(gd^3)^{1/2}\}\ x\ (\Upsilon_s / \Upsilon -1)^{1/2}]$

And

τ^t_*= Dimensionless grain shear stress

$= \Upsilon R S_0 / (\Upsilon_S - \Upsilon)\ d$

$= \Upsilon R S_0\ x\ [n_S/n]^{3/2}\ / (\Upsilon_S - \Upsilon) d)$

In which q_B= bed load in N/s/m

d = mean size of sediment

R = hydraulic radius of the channel

Υ = unit weight of water

Υ_S=unit weight of sediment particles

n = Manning's coefficient for the whole channel

n_S= Manning's coefficient of particle roughness

R^t= hydraulic radius corresponding to grain roughness

S_O = longitudinal slope of the channel

The suspended load of a river/stream can be measured by taking sample of sediment laden stream water. The collection of sample is done through specially designed sampler. The sediment from the collected sample of sediment laden water is removed by filtering and its dry weight determined. It is usual to express suspended load as parts per million (ppm) on weight basis as

C_s = [Weight of the sediment in sample/weight of (sediment + Water) of the sample] X 10^6

Thus, the sediment transport rate in a Stream of discharge Q m^3/s is

International Journal of Advance Research in Science and Engineering
Volume No.08, Issue No.05, May 2019
www.ijarse.com
IJARSE
ISSN: 2319-8354

$Q_S = (Q \times C_{S\,x}\ 60 \times 60 \times 24)/10^6 = 0.086$ QC Tonnes/day

Routine observations are necessary for estimation of suspended load. By establishing relationship between Q_s and Q (m^3/s) we may derive sediment rating curve. The relationship between Q_s and Q can be represented as $Q_S = KQ^n$

Where, Q= stream discharge

Qs=sediment transport rate

N=2, because exponent is usually around 2

By the way of estimation of sediment transport load, it would easily be quantified how much river bed, topography, bank instability are altered or likely to be altered.

4. DISCUSSIONS

The dust particles arising out from the sand mining contribute air pollution in and around the sand mining areas. Continuous vehicular movement through the road and other human activities may be responsible for high concentration of NO_2 and SO_2 in the ambient air. High concentrations of dust can be a health hazard in terms of respiratory disorders such as asthma and irritating the lungs and bronchial passages. For assessing seasonal variations of concentration of particulate matter and other gaseous pollutants, air quality monitoring shall be carried out using Respirable Dust Sampler. The concentrations of PM_{10}, SO_2 and NO_2 in the ambient air are needed to compare with the baseline ambient air quality data. For assessing gaseous pollutants such as NO_2 and SO_2, the hourly mass concentration values shall be analyzed and compared with the prescribed National Ambient Air Quality Standard.

Noise can be an issue because mining activities involved noise generation while extraction using with machine and transport. The continuous vehicular movements for loading or unloading of sand, excavation sand by excavator etc. are also contributing significant level of noise pollution in and around the sand mining areas. Therefore, evaluation of noise pollution load and its mitigation is a big challenge like other environmental components such as air and water. As the high noise level has resulted significant adverse health impacts, therefore, it needs to be understood that interpreted noise levels (L_{eq}) should not exceed the prescribed ambient standards. Appropriate mitigation measures, mass awareness among the general people etc. are recommended as a part of minimizing the noise pollution associated problems of sand mining.

For assessing detrimental effects due to in-stream sand mining, various water parameters are considered for laboratory analysis. The important water parameters include Dissolved Oxygen, Bio-chemical Oxygen Demand, pH, Turbidity, Conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Alkalinity, Chloride, Nitrate, and Chemical Oxygen Demand. To understand the behaviour of water quality, evaluation of 11 important water parameters are very necessary. Dissolve oxygen is one of the most important parameter in determining the quality of water. To determine the assimilative capacity of a stream or river, analysis of dissolved oxygen concentration is one of the most important considerations. Dissolved oxygen concentration is influenced by the source of the raw water, sewage, temperature, chemical and biological processes. Depletion of DO indicates considerable utilization by organic and inorganic compounds, i.e. contamination from domestic and industrial wastes. In many water samples, less DO concentrations are being observed which on the other hand represent high concentration of turbidity in the river water. If analytical value of turbidity in water samples shows high concentration, it is obvious that turbidity in water is mainly due to suspended particles or colloidal matter in the water. It should understand from the analysis of the results that the pH of water sample is within the neutral range or not. The value of electrical conductivity indicates the ability of the water to conduct an electric current and depends upon the number of ions or charge particles in the water. Conductivity also used to estimate the soluble salt concentration in water sample, and is commonly used as a measure of salinity. Total solids are principally inorganic salts and small amount of organic matter. Total solids present in surface water are basically originated from natural sources, sewage, and surface run-off. TSS presence indicates that there is Suspended Matters in the river water. In contrast to total suspended solid, total dissolved solid (TDS) presence in water samples shows dissolved matter in the water. Nitrate is also one of the important parameters in determination of pollution load of river water. As per the CPCB standard nitrate concentration in Surface Water Source is limited to 10 mg/L. Less concentration of Nitrate less fertile top soil deposits in along the both banks of river. The biological oxygen demand is an empirical measurement of the oxygen requirements of a stream or river or water bodies. However, exceeding value of 3 mg/L is also permitted for washing & bathing purpose (Class-B).

In order to reduce the adverse impacts on environment from the river bed sand mining, a number of engineering techniques that can be employed [Langer, 2003]. It is fact that major causes of adverse impacts from in-stream mining are the removal of more sediment than the system can replenish. The course materials transported by a river (bed load) commonly are moved along the channel bed. It is believed that by calculating the annual bed load, the environmental impacts from in-stream mining can be avoided. Therefore, amount of sediment that passes during a given period of time for the in-stream mining site should be calculated. Moreover, how much coarse material is or is being moved, how long it remains in motion and how far it moves are purely depends on the size, shape, and packing of the material and the flow characteristics of the river. Because, the bed load changes varies from hour to hour, day to day, and year to year. Estimating annual bed load rates is a dynamic process involving careful examination.

5. CONCLUSION

The sand mining activities as a whole have significant adverse impacts on environment. Therefore, strict regulatory regime is necessary. There is a need to have appropriate guidelines from the Government Level for long term management of sand extraction. The present paper is an attempts towards emphasizing monitoring and investigation techniques on geo-environmental issues that will provide data on various environmental qualities including profile change and sediment transport capacity of the river to evaluate the long term environmental effects of the mining activities both up-steam and downstream of sand extraction sites. This paper is also intended to enable various stakeholders such as authorities, sand mining operators and research scholars to acquire good understanding about the methods of laboratory techniques.

IJARSE
ISSN: 2319-8354

6. ACKNOWLEDGEMENTS

I would like to express my profound thanks to Sri Amarendra Jamatia, Asstt. Environmental Engineer of Tripura State Pollution Control Board for his kind supports.

REFERENCES

[1] Collins, B. D. and Dunne, T (1990). Fluvial Geomorphology and River-Gravel Mining. *Special Publication 98, Division of Mines and Geology*, California Department of Conservation, 29 p.

[2] Ghose, M.K. (1989). Land reclamation and protection of environment from the effect of coal mining operation. *Mine- tech,***10** (5), 35- 39 (1989).

[3] Kondolf, G. M. et. al., (2001). Process-Based Ecological River Restoration: Visualizing Three-Dimensional Connectivity and Dynamic Vectors to Recover Lost Linkages. *Ecology and Society***11**(2): 5.

[4] River Sand Mining Management Guideline (2009). Ministry of Natural Resources and Environment, Department of Irrigation and Drainage , Malaysia.

[5] Saviour, M. N. (2012). Environmental Impact of Soil and Sand Mining: A Review. *International Journal of Science, Environment and Technology*, Vol. 1, No **3**, 2012, 125 – 134.