(20-10)

Annexure- VI

PROJECT COMPLETION REPORT

Ten bound copies of the Project Completion Report to be submitted. Each copy should consist of part A- Summary Report and Part- B Comprehensive Report. Also submit one soft copy of the completion report and a poster of approx. size (4 feet X 6 feet) of the salient features of the achievements made in the project.

The Cover page should have following details:

DST File No.NRDMS/11/1416/08, Date: 14/10/2008.

1. Project Title:Exploration of native flora and in vitro study to assess their efficiency in removal of water pollutants

2. Duration of Project: From 04/02/2009 To 04/02/2013

3. Principal Investigator:

   Name :Prof. K.P. Sarma

   Institute :Tezpur University

4. Co- Principal Investigator:

   Name :Dr. Ashalata Devi

   Institute :Tezpur University

5. Collaborating Organizations

Organisation	Team members	Activities/Tasks Assigned
NERIWALM(Tezpur,Assam)	Prof. S.C. Patra	To create data base of the potential herbs

File.
09/8/16

Part A- Summary Report

1. Project Objectives:

Objectives as per the approved Project	Fully/Achieved/ Partially Achieved *(indicated shortfall)*	Reason for partial Achievement
1.Assesment of the selected non-toxic herbs (aquatic and terrestrial) for remediation of heavy metals and arsenic.	FullyAchieved	
2.Remediation of heavy metals and arsenic from water using selected species.	Fully Achieved	
3.Application of potential plants for the treatment of waste water.		
4.Creation of a database of the potential herbs	Not yet Achieved	As per decision this part will be carried out at NERIWALM

1. Deliverables:

Objectives as per the approved Project	Fully/Partially/ Not Achieved	Reason for partial Non Achievement
Assesment of 19 selected samples non-toxic herbs (aquatic and terrestrial) for remediation of heavy metals and arsenic from three watershed of Tenga, Pinjoli and Shergaon of Arunachal Pradesh of Eastern Himalayas have been made.	Fully Achieved	
Experiments regarding the remediation of heavy metals (as mentioned in part B point No. 4), from water using selected species have carried out and such herbs were identified.	Fully Achieved	
Such potential herbs have also been applied for the treatment of waste water.	Fully Achieved	
4.Creation of a database of the potential herbs ,this objective is part of a Separate project	yet to be Achieved (Separate project)	This part of the objective will be carried out at NERIWALM

2. Specific Benefits/Outcome :

i). Patent, if any :Nil

ii). Product/Process developed : Technology regarding remediation of heavy metals using non-toxic herbs have been developed.

iii). List of Publications arising from the project: 2

ii). Product/Process developed : Technology regarding remediation of heavy metals using non-toxic herbs have been developed.
iii). List of Publications arising from the project: 2

J. of Env.research and Development: Impact Factor: 0.607, Copies of the Papers are being attached.

(Indicate Impact Factors of the Journals: attach Copies of the Papers)

iv). Linkages developed: Colloborative research work with Dr. Dipankar Chakraborti Director, School of Environmental Studies (SOES) Jadavpur University, Kolkata.

v). Manpower trained, give details.: One Research Scholar got Ph.D. degree, One project fellow has been trained during this period.

3. Summary of significant S&T Achievements
   (Provided in bullet form)
   - *One Research Scholar got Ph.D. degree*
   - *Two Resarch papers published*
   - *Two more Resarch papers in the pipeline.*
   - *19 herbs have been identified for remediation of heavy metals from drinking water and waste water.*

4. Project Budget *(Final)*: Rs. 1070668/

5. Suggestions for Utilization of Project Outcome, *(Give tangible road map, name specific Industrial Units)*

   The findings of the project will be useful

   - To rural population for obtaining safe drinking water: By using the herbs (names are cited below) collected form the three watersheds namely Tenga, Shergoan and Pinjoli.Pb As and Cd can be removed .
   - To industries for treatment of waste water: In ETP of various industries Viz. remediation of Pb, As and Cd can be achieved with the help of herbs mentioned below.
   - To R & D institutions and laboratory for further research: Using this as a base line data R & D institutions and laboratory may further carry out research in this direction.
   - To PHED: To provide safe drinking water by removing Pb, Cd and As.
   - To state pollution control board providing solution for getting safe drinking water.

Date 12/4/13

(Signature of PI)

Professor
Deptt. of Environmental Science

Annexure VI Contd.

PROJECT COMPLETION REPORT

Part B- Comprehensive Report

(The Comprehensive Report should be precise in details and self-contained)

1. Project Title : Exploration of native flora and in vitro studies to asses their efficiency in removal of water pollutants.

2. Product/Process as an outcome of the project, identify Beneficiaries.

- To rural population for obtaining safe drinking water
- To industries for treatment of waste water viz. in ETP of various industries
- To R & D institutions and laboratory for further research
- To PHED of Government for providing safe drinking water
- To state pollution control board providing solution for getting safe drinking water.

3. Scientific Description of the Product/Process. Give Specifications/Standards for the same:

The powdered herbs sample of the different plants was prepared by standard procedure. The samples after collection were sent t further o BSI Shillong for identifications of its taxonomic position. The samples were characterized with the help of FTIR, CHN analysis, etc

4. Methodology adopted for Development of the product/process (State briefly in 300 words).

Chemicals:

All the chemicals used for the experiment were of AR Grade. Preparation of Aqueous Solution Arsenic, cadmium and lead were used as adsorbate in this study. The stock solutions containing 1000 ppm concentration of arsenic, cadmium and lead were prepared by dissolving the sodium arsenate, cadmium chloride and lead nitrate respectively in distilled water and were used in the experiment. Other concentrations (10, 30, and 50 ppm) were prepared from this stock solution by serial dilution.

Experimental Procedure:

Batch adsorption experiments were carried out to study the effect of initial metals ion concentration, contact time and pH on the adsorption of cadmium, lead and arsenic. The plants used in the study are *Equisetum berbilin, Pteridium aquilirum , Polypodium vulgera, Pattentila fulgans, Pteris semipinata, Pteris longifolia, Pteris vittata, Pteris sps., Arthemesis lehmani, Devellis harkeri, Rumex hastatus, Gnaphalium luteoalbum* L.,*Gnaphalium hypoleueum* DC, *Gynura Sp. Boehmerialisterifriis, Polygonummolle D.*Don, *BoehmeriamacrophyllaHornem, BoehmerialisteriFriis and Cyphomandrabetacea(Cav.)*sendtn,. Adsorption studies were carried out by suspended 1g of each adsorbent on 100 ml of metal solution containing 10, 30 and 50 ppm of cadmium, lead and arsenic. The samples were stirred in magnetic stirrer. Samples were withdrawn after 10, 20 and 30 minutes intervals. At the end of each experiment, the suspensions were filtered, after which the concentrations of cadmium, lead and arsenic were determined by ICP-OES (Perkin Elmer optima 2100 DV,).

Estimation of removal percentage of metal ions by plant materials:

Amount of removed material by plants through series of batch investigations were determined by the following equation:

$$\text{Removal \%} = [(Ci - Cf)/ Ci] \times 100$$

where,

Ci =. initial concentration (ppm) of metal ions in solution

Cf =final concentration (ppm) of metal ions in solution.

Plant culture:

From the collected samples few were chosen for removal of heavy metals after characterisation. Plants were cleaned thoroughly with distilled water to remove dust and any adhering particles. The plants were then dried in an oven at 70 °C in brown paper bags for 8hrs. The dried leaves were crushed and blended to powder form using a grinding mill and then stored in an airtight container for further use to avoid contact with moisture.

5. Scientific/Technological Formulation giving underlying Basis (Provide sufficient details)

Mechanism of Metal Biosorption:

Metal biosorption is a complex process. The mechanisms involved in the biosorption process include chemisorption, complexation, adsorption complexation on surface and pores, ion exchange, micro precipitation, heavy metal hydroxide condensation onto the biosurface, and surface adsorption. To understand how metals bind to the biomass, it is essential to identify the functional groups responsible for metal binding. Most of the functional groups involved in the binding process are found in cell walls. Plant cell walls are generally considered as structures built by cellulose molecules, organized in micro fibrils and surrounded by hemicellulosic materials (xylans, mannans, glucomannans, galactans, and arabogalactans). The behaviour of cellulose as a substrate is highly dependent upon the crystallinity, specific surface area, and degree of polymerization of the fibres being studied. Cellulose can sorb heavy metals from solution. The adsorption mechanisms of heavy metals onto the adsorbent vary widely and depend upon the heavy metals under investigation, the degree of functionalization and the type of adsorbent. Most agro-based adsorbents interact with metallic species through binding of the metal ion and cellulose/lignin units in the active sites. This can be through binding two hydroxyl groups in the cellulose/lignin units or through binding the cellulose units together. Hydrogen bonding has also been found to be responsible for the adsorption mechanism in some systems of heavy metal removal.

Adsorption theory

Before studying the adsorption of heavy metals using different adsorbents from drinking water, it is necessary to review the adsorption theory briefly. Adsorption can be utilized as a treatment process to remove highly undesirable compounds from feed water. It involves the separation of undesirable compounds from the liquid phase, the binding of components to a surface, and their accumulation at the surface of the adsorptive media. Adsorption is a mass transfer phenomenon, which involves accumulation of adsorbate onto adsorbent surface. The adsorption process is controlled by electromagnetic interactions. These interactions include as a result of binding forces between atoms, ions and molecules of an adsorbate and an adsorbent surface. Four types of adsorption are identified, exchange, physical, chemical and specific adsorption. Exchange adsorption involves electrostatic attraction of opposite charge between liquid-solid phases. Physical adsorption occurs as a result of the action of Van der Walls forces which involve intermolecular attraction. Chemical adsorption is due to reactions between adsorbate and adsorbent. Specific adsorption involves the interaction between adsorbate and adsorbent without adsorbate change .

Adsorption is significantly affected by adsorbate concentration, pH, surface charge, and presence of competitive ions (MWH 2005). The adsorbent selection is based on its surface area, affinity towards adsorbate of interest, and physical strength (shape, grain size).

Mechanisms of adsorption

Adsorption isotherms and spectroscopic studies can be used to understand the mechanisms of adsorption process.

Adsorption isotherms (Adsorption equilibrium)

The adsorption equilibrium for any particular adsorbent-adsorbate system can be Called an adsorption isotherm because an isotherm is the distribution of solute between the liquid phase and the adsorbed phase at a specified temperature. Adsorption isotherms are important to explore the adsorption capacity of the adsorbent, to evaluate adsorbent feasibility and applicability. The adsorption process can be described based on any of the several adsorption isotherms, including Freundlich, Langmuir, Brenaur, Emmet and Teller (BET), Dubinin and Raduskevich (D-R), and Polanyi. The appropriate model for a particular component depends on the characteristics of the system. The energetic heterogeneity or uniformity of the adsorptive surfaces is an important factor in finding a suitable model for a particular adsorbate. For single-solute adsorption, the Freundlich and the Langmuir are the more common isotherm models. The following well known empirical and practical Freundlich equation explains adsorption data reasonably well:

$q_e = KC_e{}^{1/n}$ (1)

The linear form is as follows:

$\log(q_e) = \log(K) + 1/n \log(C_e)$ (2)

where q_e (unit mass of adsorbate/ mass of adsorbent) and C_e (units of mass/volume) are equilibrium surface and solution concentrations, respectively. K and 1/n are constants for a given system; 1/n is unit less, and the units of K are determined by the units of q_e and C_e. K states the capacity of the adsorbent for the adsorbate and 1/n is a function of the strength of adsorption. For fixed values of C_e and 1/n, the larger the value of K, the larger is the capacity of q_e. For fixed values of K and C_e, the smaller the value of 1/n, the stronger the adsorption bond. As 1/n becomes very small, the capacity tends to be independent of C_e, and the isotherm plot approaches the horizontal level; the value of q_e is then basically constant, and the isotherm is termed irreversible. If the value of 1/n is large, the adsorption bond is weak, and the value of the q_e changes obviously with small changes in C_e. The Freundlich isotherm is based on the assumption that the adsorbent has a heterogeneous surface composed of different classes of adsorption sites. The Langmuir equation can be linearized as shown below.

$q_e = q_{max}bC_e/1 + bC_e$ or $1/q_e=1/q_{max}\,bC_e+1/q_{max}$ (3)

where b and q_{max} are constants. q_{max} represents the maximum value of q_e that can be achieved as C_e is increased. The constant q_{max} corresponds to the surface concentration at monolayer coverage. The constant b is related to the energy of adsorption and increases with the increase in adsorption bond strength. The basic assumption of the Langmiur isotherm is that adsorption of solutes occurs at specific homogeneous sites and forms a monolayer.

Kinetics of adsorption

The rate of sorption is one of the most important factors in evaluating the efficiency of sorption and in determining the size of water treatment unit processes. In adsorption studies, process kinetics describe the rate at which species are transferred from the solution to the pores of an adsorbent. The rate of adsorption determines the equilibrium condition and the detention time required for treatment. In order to estimate the rates of adsorption and to identify the behavior of the adsorption, the pseudo first order Lagergren equation and the pseudo- second order equation are widely used . A simple kinetic analysis of adsorption is the pseudo first-order equation in the form:

$dq_t/dt = k_1 (q_e - q_t)$ (4)

Where k_1 (1/min) is the rate constant of pseudo first-order adsorption, q_e (mg/g of dry weight) is the amount of metal ion sorbed at equilibrium, and q_t (mg/g of dry weight) is the amount of metal ion on the surface of the sorbent at any time t (min). By applying the boundary condition $q_t = 0$ at $t = 0$, equation (4) becomes

$\log (q_e - q_t) = \log q_e - k_1 t$ (5)

Instead of the pseudo first-order Lagergren equation, a pseudo- second order equation was recently described to explain the adsorption kinetics. The pseudo- second order equation is as follows.

$t/qt = 1/k_2 q_e{}^2 + 1/q_e\, t$ (6)

Where k_2 is the rate constant of adsorption (g/mg min) and h is the initial sorption rate (mg/g min). As time approaches zero ($t \rightarrow 0$), h can be defined as:

$h = k_2\, q_e{}^2$ (7)

The initial sorption rate (h), the equilibrium sorption capacity (q_e), and the pseudo second order rate constant (k_2) can be determined experimentally from the slope and intercept of the plot of t/q versus t.

To explain the diffusion state of adsorbate on adsorbent, the rate constant for intra particle diffusion (k_{id}) is given by Weber and Morris (1972). The equation is as follows:

$q = k_{id} t^{1/2}$ (8)

The steep linear portions generally represent intra particle diffusion within pores of adsorbent, while the plateaus are attributed to the equilibrium.

6. Further Work required, if any to get full Benefits or enhance Utilization.
   Three watersheds viz. Tenga, Pinjoli and Shergaon of Arunachal Pradesh of Eastern Himalayas have huge number of non toxic herbs yet to be identified and to examine their potential phytoremediation behavior. The local people traditionally have been using some of them as medicinal herbs. The present data base and results of experiments will be helpful in elucidating the characteristic of these herbs and their uses
7. Recommendations for Utilization of the product/process. Give Concrete Steps.
   From results of the present research we recommend that following herbs can be used for remediation of

Signature of the PI

Date :

Professor [illegible]
Dept. of Environmental Science

Name of the PI : Prof. K.P. Sarma

Email : sarmakp@tezu.ernet.in

Telephone no.9435180776
Place:Tezpur

Annexure A

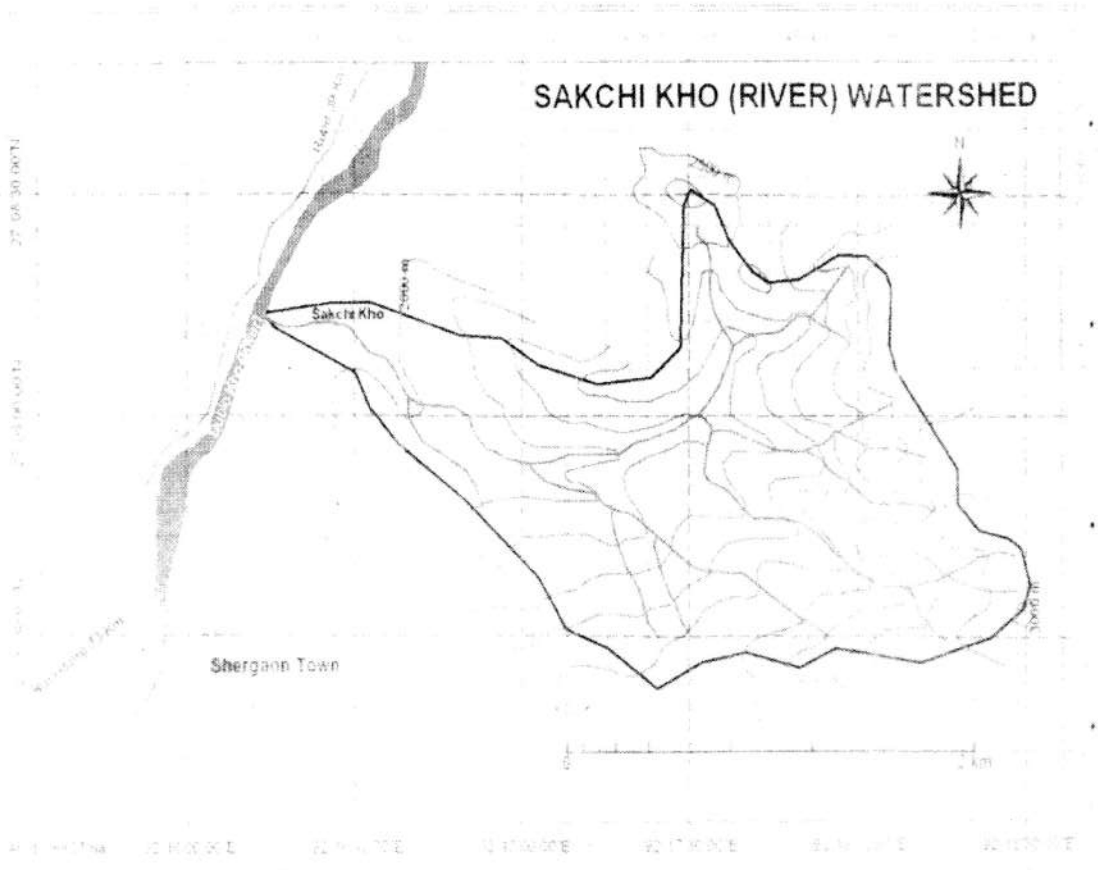

Fig 1: GIS map of Tenga watershed

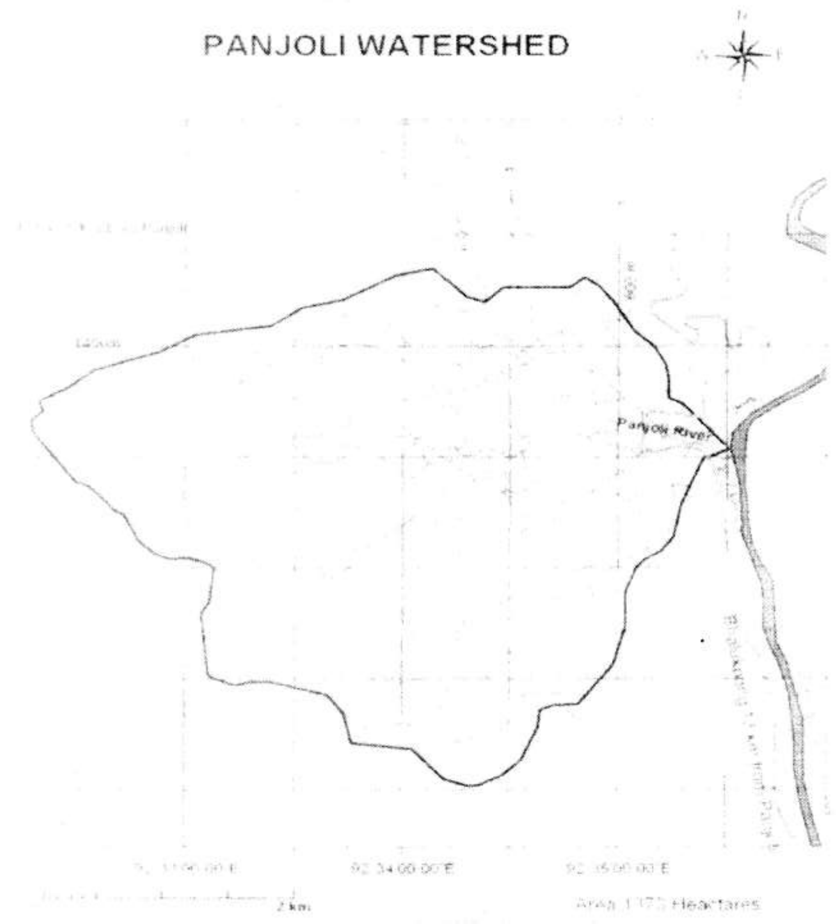

Fig 2: GIS map of Shergaon watershed

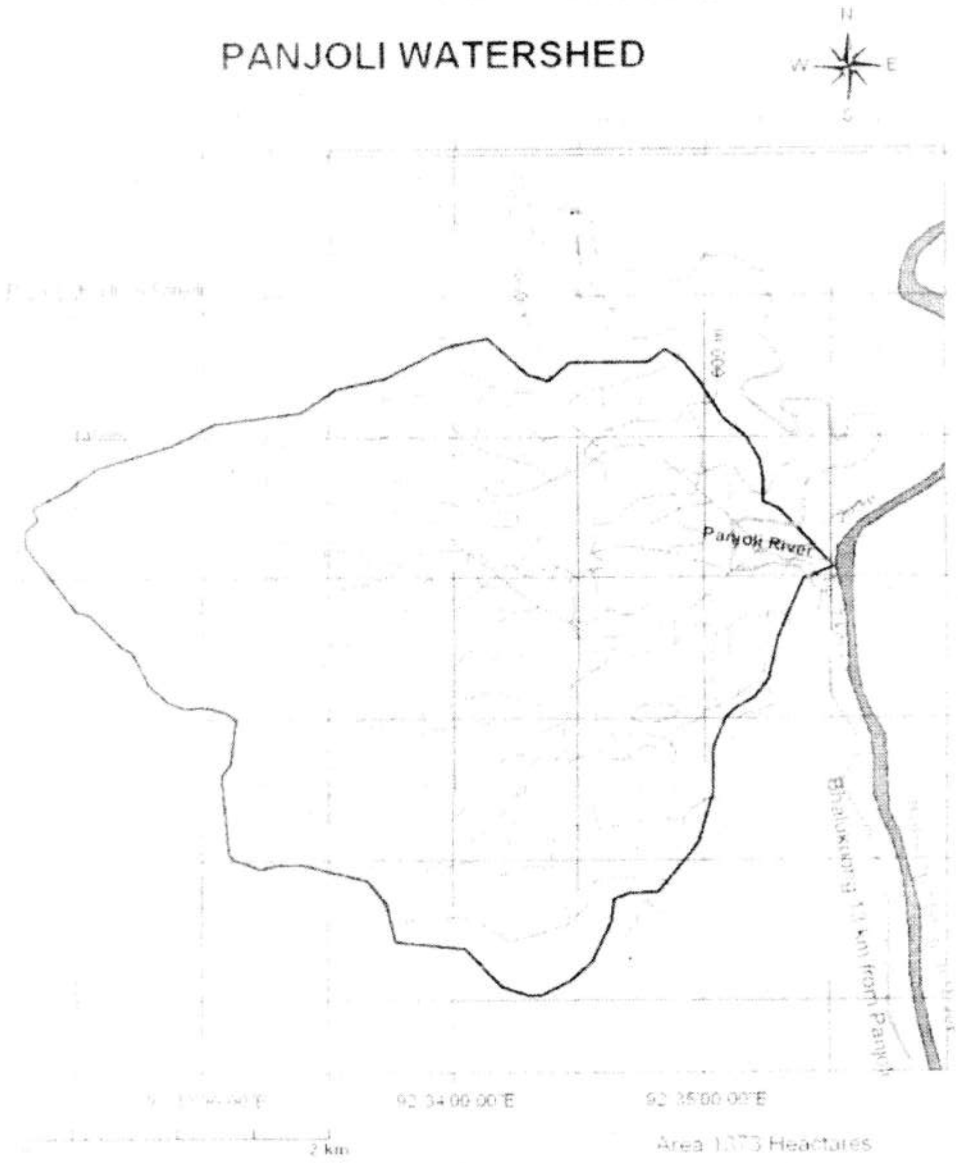

Fig 3:GIS map of Panjoli watershed

.UTILIZATION CERTIFICATE (TWO COPIES)

FOR THE FINANCIAL YEAR 2012-13

1. Title of the Project/ Scheme: Exploration of native flora and in vitro study to asses their efficiency in removal of water pollutants.
2. Name of the Institution: Tezpur University
3. Principal Investigator: Prof. K. P.Sarma
4. Dept. of Science & Technology letter No. & date sanctioning the project: NRDMS/11/1416/08, Date: 14/10/2008.
5. Head of account as given in the original sanction letter:
6. Amount brought forward from the previous Financial year quoting DST letter No. and date in which the authority to carry forward the said amount was given
   i Amount -RS. 27115.00
   ii Letter No. NA
   iii Date
7. Amount received during the financial year (Please give DST letter no/ order date)
   i Amount: Rs.250000.00
   ii No: 100/IFD/11321 / 2011-2012
   iii Date: 19/03/2012
8. Total amount that was available for expenditure (excluding commitments) during the financial year (S.No. 6+7) Rs. 222885.00
9. Actual expenditure (excluding commitments): incurred during the financial year (Upto 31st March) Rs. 217253.00
10. Balance amount available at the end of the financial year: Rs 5632.00
11. Unspent balance refunded if any(Please give details of cheque, No. et): Rs 5632.00
12. Amount to be carried forward to the next financial: NA
    year (if applicable)

UTILIZATION CERTIFICATE

Certified that out of Rs 250000.00 of grants-in-aid sanctioned during the year 2012-2013 in favour of The Registrar, Tezpur University under the Department of Science & Technology Letter No. NRDMS/11/1416/08 dated 14/10/08 and Rs. -27115.00 on account of unspent balance of previous year, a sum of Rs.217253.00 has been utilized for the purpose of implementation of the project for which it was sanctioned and that the balance of Rs.5632.00remaining unutilized at the end of the year has been surrendered to Government (vide Demand Draft No. 893494.....18/12/13 dated)/ ~~will be adjusted~~ towards the grants-in-aid payable during the next year i.e..

Signature of PI
Date 03/10/13

10/10/13
Signature of Registrar/ Signature of Head
Registrar
Tezpur University
Date

Accounts Officer of 10/10/13
the Institute
Finance Officer
TEZPUR UNIVERSITY
Date

For S. Hazarika & Co.
Proprietor
M. NO. 050557
F.R. NO. 323835E

FINAL STATEMENT OF EXPENDITURE

1. Sanction Letter No. and date of sanctioning the project: NRDMS/11/1416/08 Date: 14/10/2008
2. Total Project cost:
   (Sanctioned/ Revised Project Cost, if applicable) 1076300.00
3. Date of commencement of Project: 04.02/2009
4. Date of Completion of Project: 04.02/2013
5. Grant received in each year (financial year):
   a. 1st Year: Rs 526300.00 (including institutional charge)
   b. 2nd Year: Rs 300000.00
   c. 3rd Year: Rs 250000.00
   d. 4th year:
   e. Interest, if any:
   f. Total (a + b + c + d + e):Rs. 1076300.00(Ten lakhs seventy six thousand three hundred only)

Statement of Expenditure (To be submitted financial year wise i.e. DOS* to 31st March of the Financial Year)

Sl.no	Sanctioned head	Funds allocated	Expenditure incurred						
(i)	(ii)	(iii)	(vi) 2008-09	(vii) 2009-10	(viii) 2010-11	(ix) 2011-12	(x) 2012-13	Total	Balance
1	Manpower	556800	18661	177167	201900	70200	88872	556800	Nil
2	Consumabales	60000	Nil	2159		37841	14346	54346	5654/
3	Travel	60000	Nil	10762		17830	31408	60000	Nil
4	contingencies	90000	12397	17603		53972	6050	90022	-22
5	Others(institutional)								
6	Equipment	200000	Nil	76700		83223	40077	200000	Nil
7	Overhead expenses	109500	Nil	36500	18250	18250	36500	109500	Nil
8	Total	1076300	31058	320891	220150	281316	217253	1070668	Nil

Amount received	₹ 1076300/
Amount spent	₹ 1070668/
Balance	₹ 5632/

Amount to be refunded: Rs 5632/ (Rupees five thousand six hundred thirty two only)

KALI PRASAD SARMA Kali Prasad Sarma

Name and Signature of Principal investigator

Date

16/10/13

Signature of the competent financial/audit authority

Finance Officer
TEZPUR UNIVERSITY

(with seal) Date

*DOS: Date of Start of Project

For S. Hazarika & Co.

Proprietor

M. NO. 050557