Annual Report 2016-2017

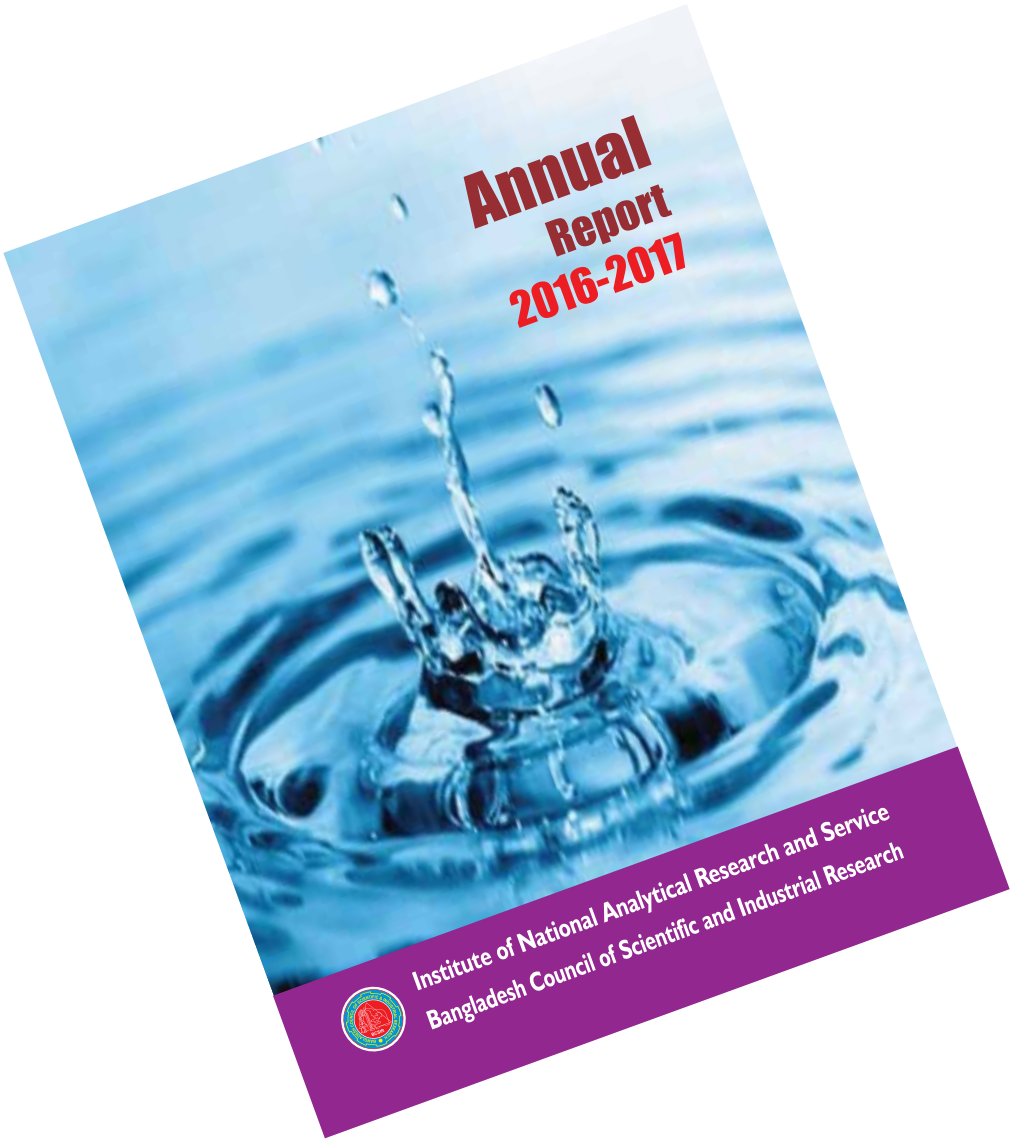
Institute of National Analytical Research and Service

Bangladesh Council of Scientific and Industrial Research

Institute of National Analytical Research and Service

Bangladesh Council of Scientific and Industrial Research

Dr. Qudrat-i-Khuda Road, Dhanmondi
Dhaka – 1205, Bangladesh
Tel: +88029664959, Fax: +88 02 58611767
Web: www.bcsir.gov.bd


Annual
Report
2016-2017
Institute of National Analytical Research and Service
Bangladesh Council of Scientific and Industrial Research

Annual Report 2016-2017

Message from Chairman, BCSIR

It gives me immense pleasure to hear that Institute of National Analytical Research and Service (INARS) is going to publish their first ever Annual Report for the period of 2016-2017. INARS has started its journey as a new institute at BCSIR since September 2016. It has a great contribution in Research and Development in the field of analytical and environmental chemistry. The researches of this institute include arsenic mitigation, water purification, environmental technology verification and identifying active ingredients in medicinal plants. This institute performs verification of arsenic technologies as mandated by Govt. of Bangladesh. By doing this, INARS contributes in achieving sustainable development goal to ensure safe water for all in Bangladesh. In addition, INARS co-operates industries in solving problems associated with ETP and discharging waste safely.

INARS also serves as a first ever ISO 17025:2005 accredited Govt. testing laboratory in Bangladesh. This laboratory has grown up as a centre of excellence of a number of sophisticated equipment such as AAS, GC, GC-MS, NMR, Ion chromatograph, Elemental analyser etc. It has received accreditation certificates from NABL, India and Bangladesh Accreditation Board on thirty four water quality parameters. The laboratory personnel have also developed their expertise in ISO 17025:2005 accreditation and are employed in expanding the scope of accreditation. Recently, the scope of accreditation has been increased to seventy seven water quality parameters.

I hope that INARS will continue its efforts in the advancement of research and service in the field of analytical chemistry in future.

Md. Faruque Ahmed
Chairman
BCSIR

Message from Director, INARS

It is a privilege to announce that the annual report of Institute of National Analytical Research and Service (INARS) is going to be published for the year 2016-2017. This is first ever annual report we are going to publish since INARS is being established in September 2016. This annual report focuses on the activities of INARS including research and development (R & D), testing service etc. The research conducted in this institute is mainly based on analytical and environmental chemistry. This institute has been involved with research in arsenic mitigation from groundwater since last decade. We have also taken a number of annual projects to develop viable options for removing heavy metal contamination in water. We hope that our research will help a great deal to ensure clean inland surface water around Dhaka city.
We have also enriched the institute with sophisticated equipment including AAS, GC, GC-MS, HPLC and NMR etc. The facility will encourage us to initiate innovative need based research in various fields in future. This year, we have conducted six projects on analytical, environmental and natural product chemistry. The outcomes of the projects will be depicted in this report. Scientists in this institute have been working relentlessly to obtain groundbreaking results in each project.

In addition, we are committed to ensure quality testing service to our stakeholders using sophisticated equipment. In this context, we have already received ISO 17025:2005 accreditation from NABL, India as a testing laboratory for thirty four water quality parameters. This year, we have extended our accreditation scope to seventy four (74) and already applied for accreditation to Bangladesh Accreditation Board.

Finally, I would like to express my gratitude to honorable chairman of BCSIR who always encouraged us to conduct all activities related to research and service in this institute. I also thank the team who tirelessly worked to prepare this report and ultimately made their efforts to a great success.

Md. Aminul Ahsan
Director (Addl. Charge)
INARS, BCSIR

Message from Convener

It was a great honor for me to be the convener of the first ever annual progress report 2016-2017, INARS publication committee. Previously, the activities of this institute were duly published in the annual report under BCSIR Laboratories, Dhaka. Since 2016-2017 fiscal year, we have planned to publish the report separately as the institute has become an independent entity in BCSIR. This current report covers a brief shot of the progress in research and development in this institute in the field of chemistry in the year 2016-2017 and other activities. This report starts with a little background of the institute and proceeds next with a brief presentation of current research and development projects and their progresses. It has ended up with providing some other sections including training, list of publications, and other routine activities.

Quality of the reports and efforts given will be evaluated by the learned readers, but I should mention here that the report has seen the light due to tireless work of a small team at this institute. We have always proved that success is must if we work as a team. Much laughter, criticism from my colleagues during preparation of this report will remain as a great encouragement for me in my career.

I would like to acknowledge the hard work done by publication committee and also admit continuous support and discussions received from everyone at the institute. I hope the next annual report will bring out more exclusive outcome of research and development on time at this institute.

Dr. Shajahan Siraj
Convener, Annual Report 2016-2017

Message from Member Secretary

It is my honor to say that the first annual report on the overall activities of INARS, BCSIR for the period 2016-2017 is ready for publication. The annual report contains the overall activities of INARS and also describes research and development, participation and offering training, seminars, conferences, workshops and analytical services rendered to different Government organization, NGO, public and private universities by the devoted scientists of this institute.

INARS is the first government laboratory in Bangladesh and only one in BCSIR that got ISO/IEC 17025:2005 accreditation. This institute is playing a vital role in arsenic mitigation in Bangladesh.

A number of state of the arts equipment were purchased through an Annual Development Project (ADP) which is enhancing the research activities as well as increasing the capacity of analytical service.

I express my sincere gratitude to the chairman, BCSIR for his continuous encouragement and support in bringing out this annual report. I would also like to express my heartiest thanks to the Director, INARS for his time to time guidance and enthusiastic support for completing this annual report. Finally, my heartiest appreciation goes to all the scientist, technologist, officers and staffs of this institute for their tremendous contribution for publishing this report.

Shamim Ahmed
SSO and Member Secretary

Publication Committee

Convener

Dr Shajahan Siraj
Senior Scientific Officer

Members

Muhammad Abdullah Al-Mansur
Senior Scientific Officer

Md. Ahedul Akbor
Senior Scientific Officer

Md. Ripaj Uddin
Research Chemist

Aftab Uddin Ahmed
Junior Experimental Officer

Member Secretary

Shamim Ahmed
Senior Scientific Officer

Background of INARS

Institute of National Analytical Research and Service (INARS)

Institute of National Analytical Research and Service (INARS) was established in September 2016. Since then INARS has been conducting research mainly in the field of analytical and environmental chemistry and natural products chemistry. This institute is specialized in doing research on water chemistry, more specifically mitigating arsenic and other heavy metal contamination in water. The current trend of research of this institute has also expanded to investigate the organic contaminants in water. A significant contribution in this area of research has come from INARS as it has been involved with arsenic removal technology verification process since last decade. Through this, the institute has come up with the solution to ensure arsenic free drinking water for everyone in Bangladesh.

Besides, INARS has achieved ISO 17025:2005 accreditation as a first ever govt. testing laboratory in Bangladesh. Initially, it received accreditation for thirty four (34) water quality parameters which has been expanded to seventy four (74) parameters this year. The institute is always committed to provide testing services compliant to international standard.

The institute has a dedicated team consisting 29 scientists, technical and other staffs. The team has been contributing in research and development since last few decades. The team is always committed to personal and professional integrity and work together to fulfill a clear vision of the institute.

Mission and Vision

Our Mission

* Carrying out innovative research that create benefit for national economy of Bangladesh.
* Provide analytical services compliant to ISO/IEC 17025:2005 standard.

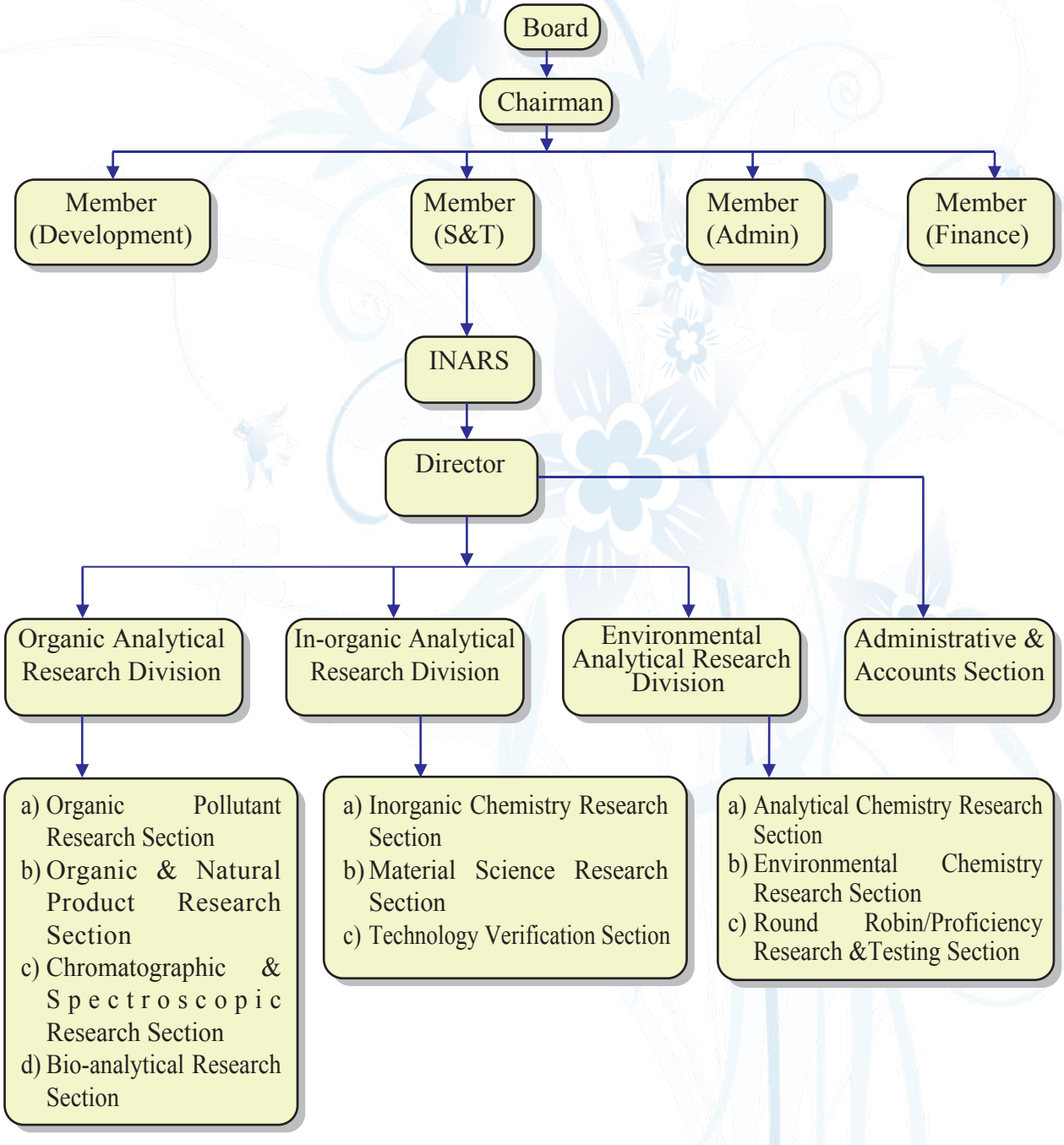
Our Vision

Achieve the status of INARS as a centre of excellence in analytical research and service by the year 2021.

Dr. Muhammad Qudrat-i-Khuda

Table of Contents

Organizational Structure



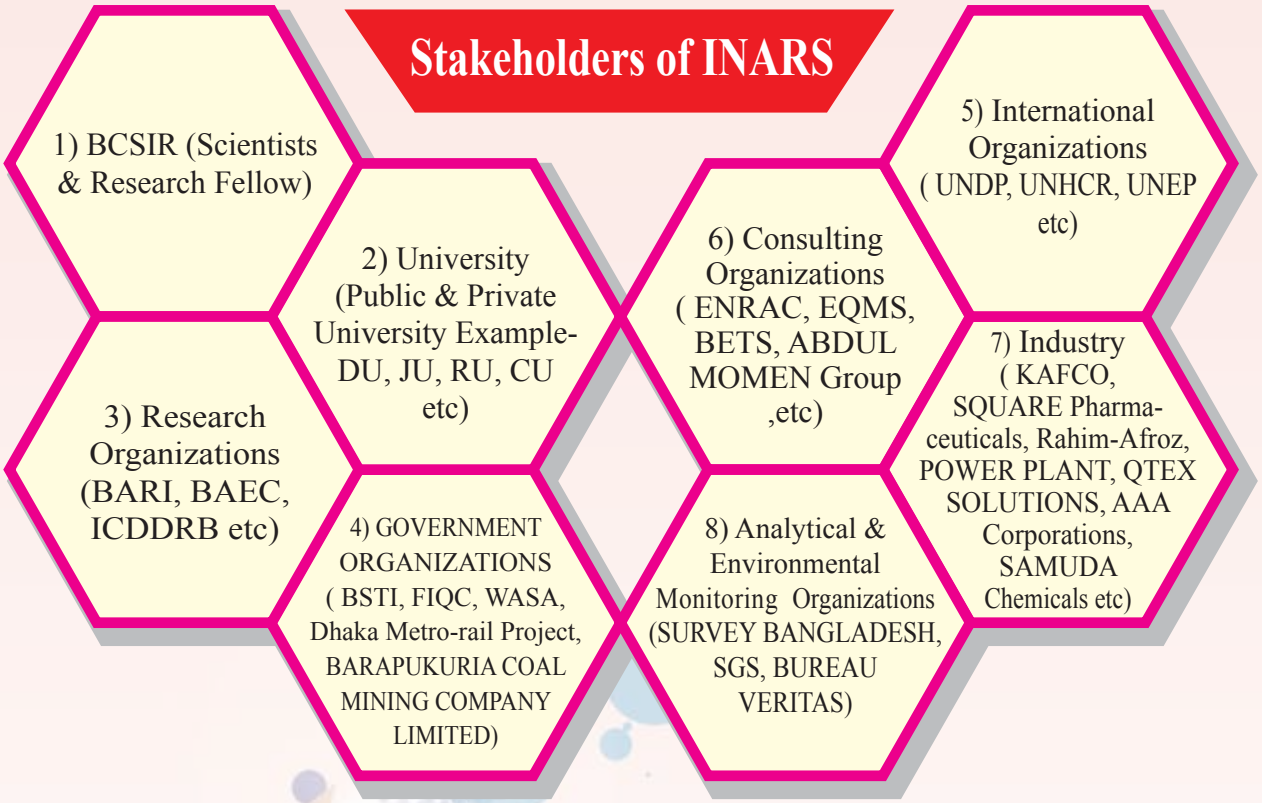
Divisions at INARS

Organic Analytical Research Division	Inorganic Analytical Research Division	Environmental Analytical Research Division
Name and Designation	**Name and Designation**	**Name and Designation**
1. Shamim Ahmed, SSO	1. Md. Aminul Ahsan, PSO	1. Dr. Shajahan Siraj, SSO
2. Mohammad Abdullah Al-Mansur, SSO.	2. Md. Ahedul Akbor, SSO	2. Shakila Akter, SSO
3. AHM Shofiul Islam Molla Jamal, SO	3. Md. Abu Bakar Siddque, SO	3. Sabina Yasmin, SO
4. Md. Ripaj Uddin, RC	4 AKM Habibur Rahman, JEO	4. Khondaker Md. Abu Taleb, Jr. Tech.
5. Aftab Uddin Ahmed, JEO	5. Nur Nabi Chowdhury, Technician	5. Ahammad Ali Islam, Lab. Tech.
6. Md. Nurul Islam, Jr. Tech.	6. Md. Jahangir Alam, Sr. Lab. Attn.	

Budget Allocation and Expenditure of INARS

Year	Allocation (Tk)	Expenditure (Tk)
2016-2017	1,77,70,968/=	1,57,77,586/=

Structure of Stakeholders of INARS



Research and Development

Annual Report 2016-2017

Development of Low cost Arsenic Removal Technologies to mitigate Arsenic from contaminated water

Md. Ahedul Akbor, SSO, PL, Dr. Mohammad Mostafa, PSO, Md. Aminul Islam, PSO, Dr. Shajahan Siraj, SSO, Shamim Ahmed, SSO, Md. Abu Bakar Siddique, SO

Introduction

Water intended for human consumption should be both safe and wholesome. Without ample safe drinking water, communities cannot be healthy. Arsenic contamination of groundwater in Bangladesh is widespread and acute and an estimated 30 million Bangladeshi (Heikens 2006) obtain their drinking water from shallow tubewells that are contaminated with arsenic above the national drinking water standard of 50 mg/I (Government of Bangladesh [GoB], 1997). Arsenic is poisonous and known cancers causing agent (Centeno et al. 2002, Loewenberg 2007) and approximately 10,000 - 30,000 Bangladeshis have already been diagnosed with arsenicosis (Heikens 2006). Thus, meeting the need for arsenic-safe.' drinking water in Bangladesh is urgent. Arsenic removal filters could help meet the needs of some arsenic- affected populations, especially in areas where no arsenic-free water sources are available. Indeed, as a supplementary option, filters could help the government.

Objectives

Developed a low cost Arsenic Removal Technology to mitigate Arsenic from the contaminated water and

1. Provide technical information governing the performance of ART with various water matrices,
2. Produce statements on the performance of ART under "real world" conditions,
3. Support large-scale future technology deployment and installations
4. Knowledge regarding the ART's ability to remove other harmful chemicals from contaminated groundwater,
5. Highlight ways and means of improving ART's performance
6. More importantly, obtain better knowledge and understanding of ARTs and their efficacy for generating safe drinking water for populations in arsenic-affected areas of Bangladesh

Progress / Outcome

A literature review on existing technologies has been conducted for developing a low coat arsenic removal technology. One of the media and possible structure of this technology has been developed. Testing process is going on to find out how much arsenic it can remove, how much water it can treat without media saturation and tried to estimate it flow rate. Now we have tested it by using synthetic water. Site selection and well characterized has been done for real water testing.

Removal of Heavy Metals from Polluted Water Using Low Cost Adsorbent Materials

Md. Abu Bakar Siddique, SO, PL, Dr. Mohammad Mostafa, PSO, Md. Aminul Islam, PSO, Dr. ShajahanSiraj, SSO, Shamim Ahmed, SSO, Md. AhedulAkbor, SSO

Introduction:

Heavy metal pollution has become one of the most serious environmental problems nowadays. The removal of heavy metals from the environment is of special concern due to their persistence. The presence of zinc, cadmium, nickel and others metals in the aqueous environment has a potentially damaging effect on human physiology and other biological systems when the acceptable levels are exceeded. Heavy metals cannot be degraded or destroyed. The conventional method for heavy metal removal includes chemical precipitation, membrane filtration, ion exchange, reverse osmosis, electro-dialysis, solvent extraction, evaporation, oxidation and adsorption. However, adsorption has proven to be economical and efficient for removing heavy metals, organic pollutants and dyes from polluted waters. In our work, a number of low cost adsorbent materials will be synthesized, processed and will be used as adsorbents for heavy metal removal.

Objectives

1. To remove heavy metals from waste water and ground water using low cost adsorbent materials.
2. To find out a suitable adsorbent materials which acts as better adsorbents for heavy metals removal.
3. To prepare an appropriate media which will help local people to remove toxic heavy metals from ground water for drinking purpose.
4. To minimize heavy metals pollution in surface water.
5. To mitigate heavy metal pollution due to industrial waste water.
6. To develop a new appropriate technology for heavy metals removal.
7. To Support large-scale future technology deployment and installations.
8. To gather knowledge regarding the ability of this technique to remove other harmful chemicals from contaminated groundwater and waste water.

Progress / Outcome:

Nine adsorbent materials including different oxides of Manganese, Graphene and their composites have been synthesized and characterized by XRD, FT-IR, SEM and TGA successfully. The synthesized materials were found as nanoparticles and will be employed as testing adsorbent for heavy metals removal.

Removal of Lead from waste water by low cost Adsorbents

Md. Aminul Islam, PSO, PL, Md. Ahedul Akbor, SSO, Shamim Ahmed, SSO, Md. Majedul Haque, SSO, Md. Abu Bakar Siddique, SO, AHM Shofiul Islam Molla Jamal, SO

Introduction

Heavy metals such as lead can often be found in industrial wastewater and their discharge to the environment poses a serious threat due to their acute toxicity to aquatic and terrestrial life which includes humans. As a result of increasing industrialization more heavy metals are being continually released to the environment and this has prornpted environmental engineers and scientists to investigate methods by which heavy metal-bearing wastewaters can be treated effectively and economically. Enhanced industrialization and discovery of various uses for lead however have caused humans to disinter it, which has caused the release of large quantities of the by-product of this material into air, soils and surface waters. It is used as an industrial raw material in manufacturing of storage batteries, television tube, printing, paints, pigments, photographie materïals, füeIs, matches and explosives. The manufacturing process of these materials produces lead-bearing wastewaters, which have to be treated and disposed of One of the largest consumers of lead is the storage battery industry followed by the petroleurn industry in producing gasoline additives. Lead concentrations in wastewater from battery manufacturing, acid mine drainage, tailing pond and steel production plants range from 0.5 to 25 mg/L.

Objectives

1. To find out a suitable and low cost adsorbent material(s) for developing a technology to remove toxic lead metal from industrial waste water.
2. To prepare an appropriate media which will be helpful for lead base industries to remove toxic lead metal from their effluent.
3. To mitigate heavy metal (Lead) pollution in our environment due to industrial waste (polluted) water.
4. To Support large-scale future technology deployment and installations.
5. To gather knowledge regarding the ability of this technique to remove other harmful chemicals from contaminated waste water.

Outcome

A nano-material, works as an adsorbent, has been synthesized using rice husk. The developed nano-material will be characterised shortly using different analytical techniques including SEM, XRF etc. Laboratory synthetic lead contaminated water has been treated using the developed nano-material. It was found that the material can successfully remove lead from water.

Chemical fingerprint profile of secondary metabolites of selected medicinal plants

Shamim Ahmed, SSO, PL, Dr. Mohammad Mostafa, PSO, Muhammad Abdullah Al-Mansur, SSO
Shakila Akter, SSO, Md. Ahedul Akbor, PL, Md. Ripaj Uddin, RC

Introduction

Plants may be regarded as libraries of small molecule secondary metabolite organic compounds with considerable structural diversity, which would otherwise probably be unavailable in a synthetic chemical laboratory. Plants have developed chemical defenses over millions of years against environmental threats such as UV radiation, reactive oxygen species and microbial attacks. Therefore phytochemicals are less toxic and biologically active. The present scenario shows the demand for plant drugs throughout the world because of its valuable phytochemicals. Now a day's new technology have made it possible to identify, screen and isolate these active compounds. The chromatographic and spectral fingerprints play an important role in the quality control of complex herbal medicines. Development of chemical fingerprints using TLC, HPLC is an effective tool for linking the identity for estimation of chemical and bio chemical markers. The advancement of TLC, High Performance Chromatography (HPLC) can provide an electronic image of chromatographic finger print and densitogram to detect the presence of a marker compound in the plant sample. It is efficient and economic for the analysis of broad number of compounds. It has the potential to determine authenticity and reliability of chemical constituent of herbal drug and formulation.

Objectives

1. To develop HPLC fingerprints to distinguish the adulterant and standardization of herbal formulations.
2. To develop analytical method for isolation of marker chemicals from the standard herbal drugs or medicinal plants.
3. To ensure the quality of the herbal drugs using modern analytical techniques, for therapeutic efficacy and safety.

Progress / Outcomes

Four medicinal plants Adhatoda vasica, Andrographis paniculata, Asparagus racemonus and Withania somnifera herbal monograph has been completed. Two compounds namely Neoandrographolides and quercetin 3-O-beta-D-glucopyranoside were isolated.

Development of value added products from Aquillaria malaccenisis Lam (Agar) and Tergetes erecta Linn (Genda phul)

Dr. Mohammad Mostafa, PSO, PL, Shamim Ahmed, SSO, Shakila Akter, SSO, Md. Ahedul Akbor, SSO, Ms. Katrun Nada, CSO

Introduction

Agar is traded in several forms from large sections of trunk to highly processed fine products including incense and perfumes. The essence extracted from agar wood is now widely used as a fragrance to manufacture beauty soaps and shampoos etc. Trade in the agar wood dates back as early as the 13th century. Agar is one of the most promising non-timber forest products (NTFPs) of Bangladesh, and earned Tk.1 300M through exports of attar (agar oil) in 2004. About 25,000 workers were engaged in cultivation, collection, processing and marketing of agar and agar-based products in that year. Despite the huge demand in local and international markets, no major extension program has so far been conducted by governments or other agencies in Bangladesh. The plant Tagetes erecta Linn. Locally known as Genda Phul (Marigold) belongs to the family Asteraceae. It is a stout, branching herb, native of Mexico and other warmer parts of America and naturalized elsewhere in the tropics and subtropics including India and
Bangladesh. The flower is useful in fevers, epileptic fits (Ayurveda), astringent, carminative, stomachic, scabies and liver complaints, skin diseases and is also employed in diseases of the eyes. The Essential Oil of Tagetes is extracted from its leaves, stem, stalk, and flowers by the process of steam distillation. The main components of this oil are limonene, ocimene, tagetone and valeric acid.

Objectives

1. To Extract, Fractionate and characterize of the active ingredients from Aquillaria malaccensis Lam and Tagetes erecta Linn.
2. To evaluate the biological activities of the extracts as well as active ingredients.
3. To develop of value added products from these active ingredients.

Progress / Outcomes

The antibacterial and antioxidant activities as well as phytochemical screening of different extracts of Tagetes erecta L flowers have been completed. Two compounds were isolated from the ethylacetate extract by Column Chromatography and identified as Erythrodiol-3-palmitate and ?-Amyrin palmitate by NMR studies.

Development and validation of analytical methods for the estimation of vitamins in medicinal and dietary products

Dr. Shajahan Siraj, SSO, PL, Md. Aminul Islam, PSO, Shamim Ahmed, SSO, Muhammad Abdullah Al-Mansur, SSO, AHM Shofiul Islam Molla Jamal, SO, Md. Ripaj Uddin, RC

Introduction

Vitamins are organic compounds, essential nutrients, which are important to human and animals for the existence of their life. Vitamins are also crucial for the maintenance of good health. Our body obtains them from our diet. Most of the vitamins needed are found in foods. Shortage of vitamins in our body can develop deficiencies and result in health issues. Often doctors prescribe vitamins supplement to make up shortages. For this reason, the estimation of vitamins in medicinal and dietary products needs to be checked and it is very essential, in order to ensure correct intake and the accuracy of the label statements.

Objectives

1. To develop a selective and sensitive analytical method for rapid quantification of water and fat soluble vitamins in various matrices.
2. To validate the analytical methods for specific vitamins in different matrix (plant products, dairy products, poultry products, beverages and drinks, candies, baby cereals and vitamin syrups etc).
3. To obtain ISO/IEC:17025 accreditation on analysis of vitamins in food supplements.

Progress / Outcomes

A literature review on existing analytical methods has been conducted to find out the possible methods for application and room for further improvement. Standards of water and fat soluble vitamins such as vitamin B1, B2, B5, B6, B9, B12, ascorbic acid, Vitamin A, D, ?-carotene etc. have been purchased separately and a mixed standard of the vitamins has been prepared. The prepared mixed standard has been analysed using High performance liquid chromatograph and separate peaks are identified for individual vitamin standard. Some parameters e.g., linearity, specificity, method detection limit are determined as part of validating the developed method. Some of the food supplementary products e.g., baby cereals, vitamin syrups have been collected from local market to examine the amount of vitamins if they comply with the concentration shown on the label of the product.

Isolation and characterization of Bioactive compounds from Anethum sowa Linn.

Muhammad Abdullah Al-Mansur, S.S.O Dr. Mohammad Mostafa, P.S.O., Md. Aminul Ahsan, P.S.O., Shamim Ahmed, S.S.O., Shakila Akter, S.S.O., Md. Ahedul Akbor, S.S.O., Mohammad Majedul Haque, S.O.

Introduction:

The main aim of this R&D Project is to discover novel, potent and selective compounds with potential activity to treat diseases. All aspects of this programme have been designed to streamline the isolation, evaluation, purification and characterization of potentially useful bioactive compounds. The purpose of extensive phytochemical research is to isolate the active constituents in the pure form to avoid unwanted effect and to ensure safe use of herbal medicines.

Objectives:

The objective of this research project is to discover novel bioactive molecules from medicinal plants such as Anethum sowa Linn. (Family: Apiaceae ; Bengali name: Shulfa, Soya, Solup, Hoilfa, Sowa) using modern separation, isolation and spectroscopic techniques. Value addition of discovered bioactive molecules will be achieved through the development of precise, rapid and sensitive analytical method of detection and quantification useable for the quality evaluation of the source, followed by the non-destructive extraction, fractionation and isolation processes. The isolated bioactive molecules will be assessed for their safety and efficacy in animal models to find out the suitable lead compounds for the clinical study. Logical modification of constituents will be attempted for improved activity.

Progress :

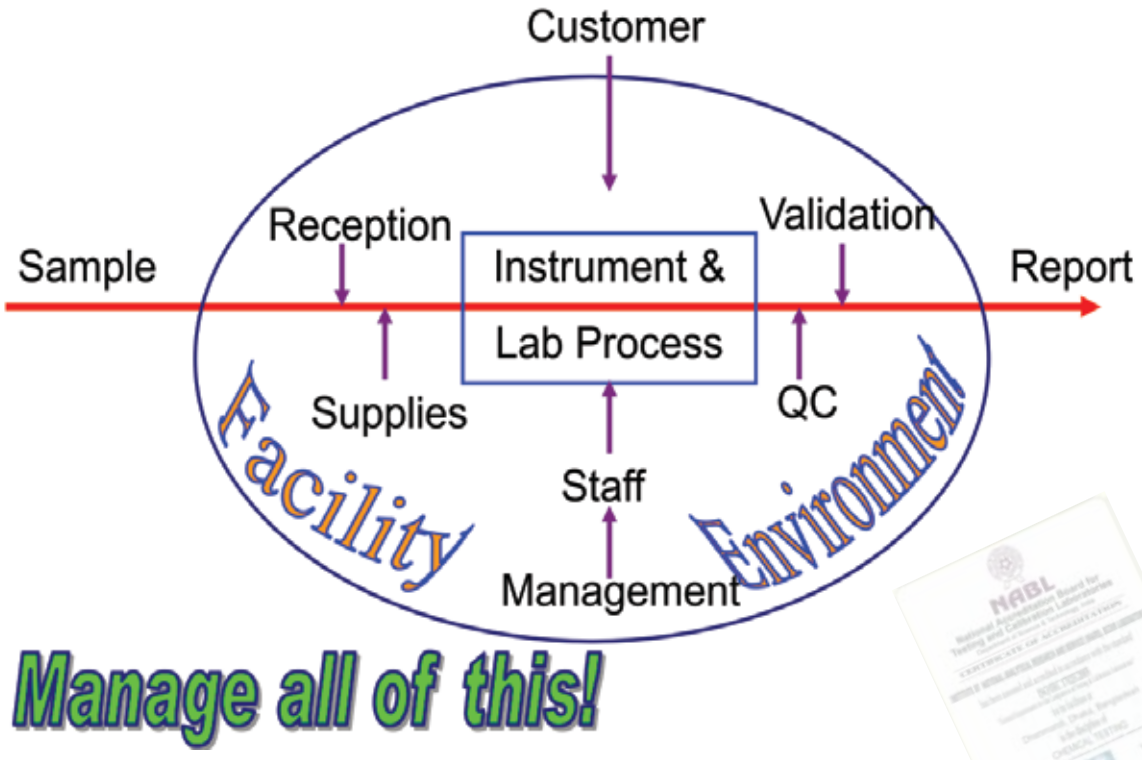
The plant Anethun sowa Linn was collected from Karanigonj, Dhaka and it was identified by Bangladesh National Herbarium .The stems and seeds of the plant were extracted separately by n-hexane, dichloromethane, ethyl acetate and methanol in successive manner. Total eight extracts from different parts of the plant were examined for their bioactivity like Cytotoxic, Antimicrobial ,Antioxidant, Thrombolytic, Membrane Stabilizing, Antidiarrhoeal , Analgesic and Hypoglycemic activity using different well established bioassay procedures. The results of these bioassays were encouraging. Preliminary phyotochemical screening of the plant extracts were performed & many valuable bioactive metabolites were found. Analyses of proximate composition, mineral, heavy metal contents and gas chromatography-mass spectroscopy (GC-MS) of different extracts have been carried out by separate experiments. The results of these analyses were significant.

ISO 17025:2005 Accreditation for international recognition

Annual Report 2016-2017

Maintaining ISO 17025:2005 accreditation at INARS

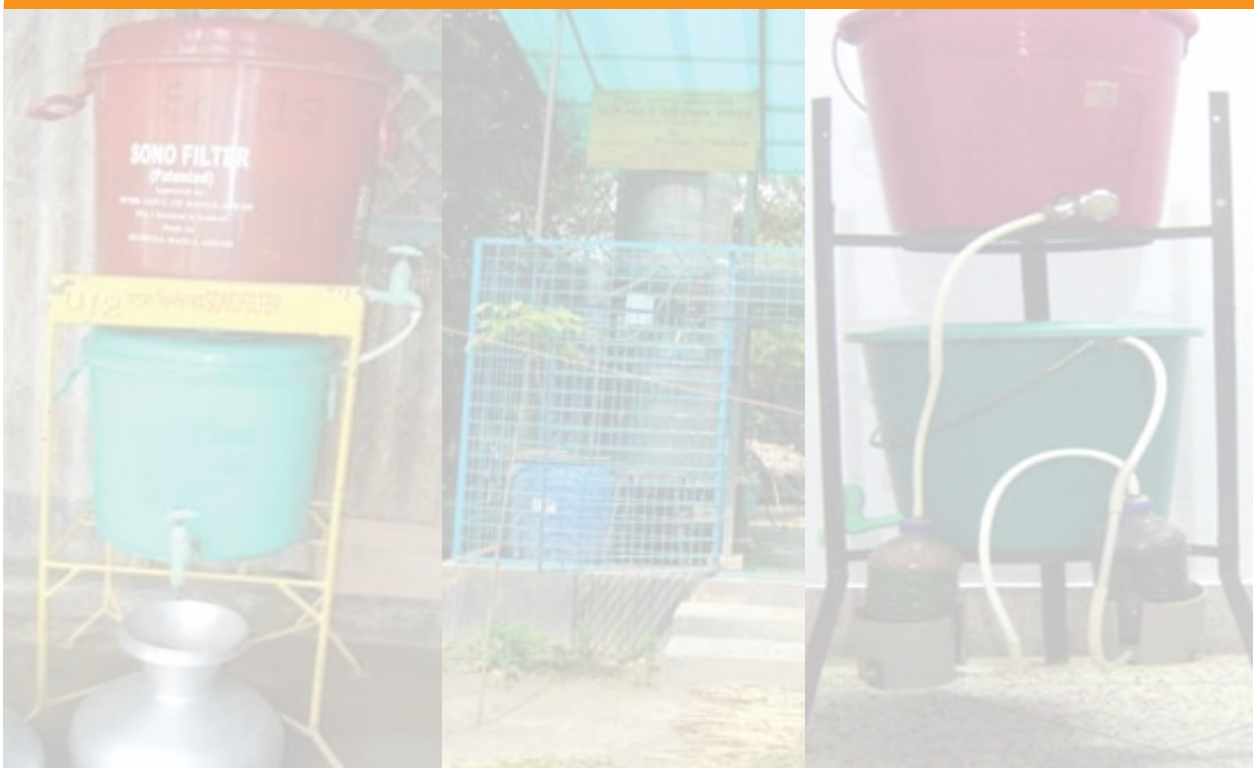
The reliability of test results produced by a laboratory is laid upon a system which follows some international standards. One of the standards is ISO 17025:2005 that must be implemented in a testing laboratory to demonstrate the reliability of test data. The sophistication of the instrument alone does not ensure good quality data, rather, a complete quality management system, as shown below in the flow chart, will offer internationally acceptable test results. In this context, INARS, formally known as analytical research division, has implemented a complete setup of quality management system since 2009. A quality management system in a testing laboratory requires a great deal of works for continual improvement of a laboratory. The works include developing quality manual (QM), standard operating procedure (SOP), quality system procedure (QSP), quality system forms (QSF), method validation, management review, internal audit etc. A list has been shown in a table below to depict the works involved in maintaining ISO 17025:2005 in the institute. By doing all these works, we received accreditation for twelve (12) water quality parameters in 2009 from NABL, India as a first ever govt. testing laboratory in Bangladesh. The scope of accreditation was expanded to twenty four (24) in 2012 and subsequently, it was increased to thirty four (34) in 2014. This year in 2017, we have applied for accreditation of seventy four (74) water quality parameters to Bangladesh Accreditation Board (BAB). Hopefully, BAB will conduct the assessment of the institute for further renewal of accreditation.



List of quality system documents developed at INARS as below:

Document Name	Number
Standard operating procedure	74
Quality system procedure	10
Quality system form	30
Method validation	74
Quality manual	1
Quality policy	1
Calibration of pipette	7
Calibration of volumetric flask	50
Control chart	12
Participation in international proficiency testing program	5
Conducting round robin in Bangladesh	7

Endeavor for safe drinking water



Annual Report 2016-2017

Attempts to ensure safe drinking water for all

Arsenic contamination in groundwater in Bangladesh is a major concern. The scientific community in Bangladesh has given their efforts since last few decades in order to mitigate arsenic in drinking water. Still, research has been going on in this field to find possible sustainable options. Arsenic removal filter has been considered as a robust option in this process. Many ARTs have evolved in the last decades to produce arsenic safe water. Most of them have not been verifiedin the real world arsenic contaminated water. Their efficacies have been projected by relying on laboratory based experiment only. Therefore, it was necessary to verify the efficacy of the filter in real world using Bangladesh groundwater. Bangladesh Council of Scientific and Industrial Research (BCSIR) is mandated by the Government of Bangladesh to verify performance claims of Arsenic Removal Technologies (ART). Subsequently, BCSIR has nominated INARS, previously known as Analytical Research Division (ARD), to perform this work in 2003. Since then, INARS has been involved with the process and continuing its effort to ensure arsenic free drinking water for everyone in Bangladesh. It is noted that ARD conducted performance claims verification of Arsenic Removal Technology (ART) in collaboration with Canadian International Development Agency (CIDA) through ETV-AM and BETV-SAM project in 2003 and 2006, respectively. We verified thirteen (13) arsenic removal technologies and six of them were certified for marketing in Bangladesh. Presently, we have received a number of applications from different proponents for verification of their technologies such as Xiano filter. In addition, we have assessed WASA supply water throughout Dhaka city to investigate any possible contamination. Currently, we have collected so called mineral water bottles from local market to examine correct level of minerals in them. In addition, we have assessed WASA supply water throughout Dhaka city to investigate any possible contamination. Currently, we have collected so called mineral water bottles from local market to examine correct level of minerals in them.

Publications, Conference, Training and Others

Annual Report 2016-2017

Achievements

Publications

Paper published in International journal

1. Chandra, S., Siraj S., Wong D. K. Y., Recent advances in biosensing for neurotransmitters and disease biomarkers using microelectrodes. Chem. Electro. Chem. 4 (2017) 822-833.

2. Siraj S., McRae C. R., Wong D. K. Y., Effective activation of physically small carbon electrodes by n-butylsilane reduction, Electrochem. Commun. 64 (2016) 35-41.

3. Hanssen B. L., Siraj S., Wong D. K. Y., Recent strategies to minimise fouling in electrochemical detection systems, Rev. Anal. Chem. 35 (2016) 1-28.

4. Salehd Ahmed., Md. Mostafizur Rahman., Ashikur Rahman Rabbi., Md. Kausar Ahmed., S.M Saiful Islam., Muhammad Younus., Bimal Bhusan Chakraborty., Shamim Ahmed., and Nasim Sultana (2016). Synthesis, Characterization and liquid crystalline properties of a series hydroxybiphenyl benzoate and biphenyl bis (benzoate). Journal of Molecular liquids 224 (2016), 265-273.

5. Uddin MN., Majumder AK., Ahmed S., Saha BK and Motalab M (2017). Development of Method for Rapid Quantification of Glucose, Fructose and Sucrose in Mango Juice by Chemometric Techniques in De-noised FTIR Spectroscopic Data. Int. J of Food Sci Nutr Diet. (IJFS) 6 (1), 338-344.

6. Shahin Aziz., Kousik Saha., Nasim Sultana., Husna Parveen Nur., Md. Aminul Ahsan and Shamim Ahmed (2016). Comparative Studies of elemental composition in leaves and flowers of Catharanthus roseus growing in Bangladesh. Asian Pac J Trop Biomed.: 6(1), 2016, 50-54.

7. Jinat Shahria Disha., Most. Hosney Ara Begum., Shamim Ahmed et.al (2016). Preparation and Characterization of Xanthan Gum-based Biodegradable Polysaccharide Hydrogels. Research Journal of Material Sciences 4(4), 13-18.

8. Rexona Khanom, Mohammad Anwar Arfien Khan, Abdul Gafur, Shakila Akter, Shamim Ahmed, Mohammad Shahjahan, Mohammad Raqibul Qadir: Synthesis of SnO2 Nanopowders for Advanced Ceramics and Electronic Sensor Transducer Devices and Characterization and Band Gap. Nanoscience and Nanometrology, Vol. 3(1), pp. 12-19, 2017.

9. M. Sarkar, J.B. Islam, S. Akter: Pollution and ecological risk assessment for the environmentally impacted Turag River, Bangladesh. J. Mater. Environ. Sci., Vol. 7(7), pp. 2295-2304, 2016

10. Nargis Sultana Chowdhury, Md Sohel Rana, Md Hossain Sohrab, Choudhury Mahmood Hasan, Muhammad Abdullah Al-Mansur and Nazia Hoque : Bioactive metabolites from two aquatic plants of Bangladesh and their associated endophytic fungi. J Pharma Care Health Sys 2016, 3:2 (Suppl), July 11-13, 2016 Kuala Lumpur, Malaysia, ISSN: 2376-0419 JPCHS, an open access journal, Volume 3, Issue 2 (Suppl), Page 90.

11. Syed Md Akram Hussain, Md Hossain Sohrab, Abu Kholdun Al-Mahmood, Md Shuayb, Muhammad Abdullah Al-Mansur and Choudhury Mahmood Hasan : Clinical use of Carica papaya leaf extract in chemotherapy induced thrombocytopaenia. www.ijcem.com /ISSN:1940-5901/IJCEM0021549, Int J Clin Exp Med 2017;10(2):3752-3756.

12. M.I.Manirul,R. Begum,M.A.Akbor,H.Mehrajand A.F.M.JamalUddin "Arsenic Accumulation by Rice from Different Concentration of Arsenic Contaminated Soil" world Applied Sciences Journal 34(1);84-88,2016

13. M.I.Manirul,R. Begum,M.A.Akbor,H.Mehrajand A.F.M.JamalUddin "Arsenic Accumulation by Rice from Different Concentration of Arsenic Contaminated Soil" world Applied Sciences Journal 34(1);84-88,2016.

14. Shahin Aziz, HusnaParvinNur, Shahal Ahmed, Aminul Ahsan, Abu Bakar Siddique and KoushikSaha, "Proximate and mineral compositions of leaves and seeds of bangladeshibom-baxceibalinn", World Journal of Pharmaceutical Research,Volume 5, Issue 7, 1-13, 2016.

15. Md. Mubarak Hossain, Faiza Tahia, Md. Abdullah Al-Mansur and Mohammad A. Rashid: 7-Methhoxy-8-Prenylated Coumarins from Murraya koenigii (Linn.) Spreng. Dhaka Univ. J. Pharm. Sci. 15(2): 155-159, 2016 (December).

16. Adeeba Anjum, Md. Zakir Sultan, Md. Al Amin Sikder, Choudhury M. Hasan, Muhammad Abdullah Al-Mansur and Mohammad A. Rashid: Bioactive Steroid and Triterpenoids from Bridelia stipularis (L) Blume. Dhaka Univ. J. Pharm. Sci. 15(2): 221-225, 2016 (December).

17. ShamsunNaher, Md. Abu Bakar Siddique, TahminaAfroz, AjitMallik, AbdusSamad and Md.Aminul Ahsan, Effect of soil and water salinity on pH, EC and the selected ion contents in different crops grown in non salinity and salinity affected areas of Bangladesh. J.Asiat. Soc. Bangladesh, Sci. 43(1), 129-133, June 2017.

Conference/Symposium/Seminar Proceedings

1. S. Siraj, S. Ahmed, M. A. Akbor, M. A. Ahsan, M. Mostafa "The role of groundwater iron oxidation in arsenic removal technologies in Bangladesh" International conference on advanced oxidation process, 3rd AOP'TUNISIA, O-S4-046, 2-4 November, 2017.

2. S. Siraj, S. Ahmed, M. A. Akbor, M. A. Haque, M. A. Ahsan, "PAHs and VOCs – A new threat to our environment in Bangladesh" Symposium on environmental chemistry for securing water quality, BJSIR, Dhaka, Bangladesh, 30 July, 2017, p21.

3. S. Siraj, S. Ahmed, M. A. Akbor, M. A. Ahsan, A. I. Kazi, "Are we ready to conduct interlaboratory comparison program in Bangladesh?" World accreditation day 2017 proceedings, Bangladesh Accreditation Board, 9 June 2017, p42-45.

Training Obtained

1. Md. Aminul Ahsan, Training on Analytical Skills Development Course 2016 (ASDC) held in Umea, Sweden on 22 August – 2 September 2016.

2. Md. Aminul Ahsan, Training on Operating System and Maintenance of Computational Tools for Drug Discovery held in BCSIR on 04 – 06 April 2017

3. Md. Ripaj Uddin, RC has participated and successfully completed the training on NMR spectroscopy held from 25-27 October, 2016 at INARS organized by Planning and Development Division, BCSIR.

4. Md. Ripaj Uddin, RC has successfully completed the training on Web page development and deployment Course (25 working days), held from 21 march -24 may 2017 organized by National Academy for planning and development Under Ministry of Planning.

5. Md. Ripaj Uddin, RC has successfully completed the training on Understanding Course On ISO/IEC 17025:2005 held from 27-29 December, 2016 organized by Bangladesh Accreditation Board.

6. Md. Ahedul Akbor, SSO Training on Basic Statistical Analysis in Industrial Research held on 19 February 2017 at RCSIR

7. Md. Ahedul Akbor, SSO and Md. Ripaj Uddin , Training on Instruction to Orgin Lab Software for data Analysis and Research Publication held on 25 May 2017 at RCSIR

8. Md. Ahedul Akbor, SSOTraining on ETP Operation and Maintenance held on 29 July 2017 at Jahangirnagar University.

9. Md. Ripaj Uddin Training on Concept of Method Validation, 19 March, 2017.Organizer: Dhaka laboratories, under Bangladesh Council of Scientific and Industrial Research (BCSIR)

10. Md. Ripaj Uddin, RC High Performance Liquid Chromatography (HPLC),18-20 June,2017.Organizer: Dhaka laboratories, under Bangladesh Council of Scientific and Industrial Research (BCSIR)

11. Shakila Akter, SSO Participated in the training course on "Operating System and Maintenance of Liquid Chromatography Mass Spectrometer (LCMS-MS)" organized by Bangladesh Council of Scientific and Industrial Research (BCSIR) held at Dhaka, Bangladesh from 18-20 April, 2017.

12. Aminul Ahsan & Md. Abu Bakar Siddique "Lead Assessor Training Course on ISO/IEC 17025:2005-General Requirements for the competence of Testing and Calibration Laboratories" conducted by Bangladesh Accreditation Board (BAB), Dhaka, Bangladesh during 04-08 December, 2016 at Ministry of Industries, 91, Motijheel C/A, Dhaka-1000.

1. Md. Abu Bakar Siddique "In House Training and workshop on Integrity Strategy in Public Service Delivery held at BCSIR on 09 February 2017".

2. Md. Abu Bakar Siddique "In House Training on Research Methodology held at BCSIR Laboratories, Dhaka on 26 April 2017".

Training Offered

1. Shamim Ahmed, SSO, Muhammad Abdullah Al-Mansur, SSO offered training to Scientists of BCSIR at INARS on NMR spectroscopy held 25-27 October, 2016.

Conference

1. Shajahan Siraj, Abdullah al Mansur, Md. Ahedul Akbor, Shakila Akter, Shafiul Islam Jamal, Ripaj Uddin attended/presented in the symposium on environmental chemistry for securing water quality , organized by BCSIR on 30 July 2017.

2. Shakila Akter, SSO participated 1st International Conference on Engineering Materials and Metallurgical Engineering. Duration: 22-24 December, 2016, BCSIR, Dhaka.

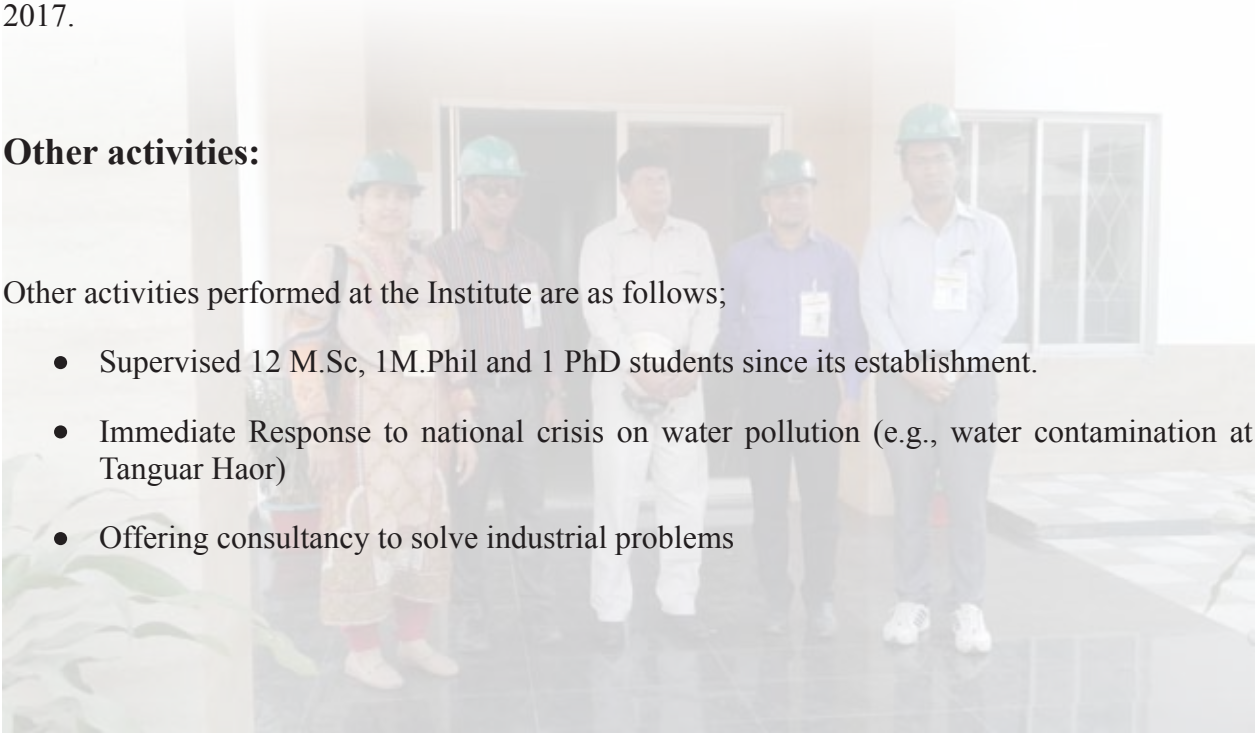
Industry visit

Shakila Akter , Md. Abu Bakar Siddique , Shafiul Islam Jamal, Ripaj Uddin has visited KAFCO on 28 February - 02 March 2017 and Intertek bd Limited, Chittagong, Bangladesh on 01 March, 2017.

Other activities:

Other activities performed at the Institute are as follows;

- Supervised 12 M.Sc, 1M.Phil and 1 PhD students since its establishment.
- Immediate Response to national crisis on water pollution (e.g., water contamination at Tanguar Haor)
- Offering consultancy to solve industrial problems



Sophisticated Analytical Instruments Facilities at INARS

High Performance Liquid Chromatograph

Gas Chromatograph

Gas Chromatograph - Mass Spectrometer

Elemental Analyzer

Atomic Absorption Spectrometer

Nuclear Magnetic Resonance Spectrometer

Analytical Services Provided by INARS

Sample Matrix

Arsenic Filter Verification	Herbs/Herbal Products
Chemical Raw Materials	Natural Product Sample
Coal	Oil & Petroleum Products
Drinking water/ Ground Water/ Surface Water/ Industrial Water/ Waste Water	Pharmaceuticals Products
Drinks/ Beverage	Quality assessment of food products
Edible oil	Soil & Minerals
Feed	Spices
Fish	Supplementary food
Food samples	Synthetic Compounds
Fruits	Vegetables

ISO 17025:2005 Accredited Analytical Parameters for Water Quality Testing

Acidity	Fluoride	Phenolic Compounds
Alkalinity	Hardness	Phosphate
Aluminum	Iron	Phosphorus
Arsenic	Lead	Potassium
Bromide	Magnesium	Sodium
Cadmium	Manganese	Sulphate
Calcium	Mercury	Total dissolved Solids
Chloride	Nickel	Total Organic Carbon
Chromium	Nitrate	Total Solids
Cobalt	Nitrite	Zinc
Conductivity	Oil & grease	
Copper	PH	


BANGLADESH ACCREDITATION BOARD (BAB)

Certificate of Accreditation

Institute of National Analytical Research and Service (INARS)
BCSIR
Dr. Qudrat-i-Khuda Road, Dhanmondi
Dhaka-1205, Bangladesh.

This laboratory is accredited in accordance with ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope of accreditation and the operation of a laboratory quality management system (Refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

File & Certificate No : 01.002.12
Issued on : 09 June 2012
Accreditation Date : 09 June 2012
Expiry Date : 08 June 2015

Director General
Bangladesh Accreditation Board (BAB)

This certificate has been issued under the authority of Bangladesh Accreditation Act, 2006 and must be returned on request. reproduction must follow guidelines in place at date of issue. For the specific tests to which this accreditation applies, please refer to the laboratory's scope of accreditation at http://www.bab.org.bd/.

Other Analytical Parameters:

Additives	Pesticides
Adulterants	Pesticides Residue
Ammonia	Poly Aromatic Hydrocarbon
Antimony	Poly Chlorinated Biphenyls
Appearance	POPS
Barium	Purity (Acetone/ Butanol/ Chloroform/ Dichloromethane/Ethanol/ Ethyl Acetate/Methanol/Propanol-2/ Xylene etc.)
Bicarbonate	Salinity
Biological Oxygen Demand	Selenium
Boron	Silica
Carbonate	Silicon
Carbon-di-oxide	Silver
Chemical Oxygen Demand	Solvent Residual (Acetone/ Butanol/ Chloroform/ Dichloromethane/Ethanol/ Ethyl Acetate/Methanol/Propanol-2/ Xylene etc.)
Chlorine	Strontium
Color	Suspended Solids
Cytotoxicity	Taste
Dissolved Oxygen	Temperature
Elemental Analysis -Carbon (%C), Hydrogen (%H), Oxygen (%O), Nitrogen (%N), Sulphur (%S)	Tin
Gold	Total Nitrogen
Metal Scan	Total Solids
Molybdenum	Total Suspended Solids
NMR sample Analysis (^{1}H, ^{13}C, Cosy NMR, Dept 45, Dept 90, Dept 135, HMBC, HSQC, NOESY, TOCSY dissolved in $CDCL_3$/MeOD/DMSO/D_2O)	Vanadium
Oxidation Reduction Potential	Volatile organic compounds

For analytical service, please visit us at https://bcsir.eserve.org.bd/users/login or contact us at the following the address:

Analytical Service Cell (ASC)
Dr. Qudrat-I-Khuda Road, Dhanmondi, Dhaka-1205, Bangladesh
Telephone: 9671108 Fax: 880-02-9671108 E-mail: asc@bcsir.gov.bd

List of Employees

List of Scientists

SL No.	Name	Designation	Field of specialization	Email	Phone
1	Md. Aminul Ahsan	Director (Addl. Charge)	Analytical & Environmental Chemistry, ISO 17025:2005 Accreditation, Method validation, Uncertainty measurement	aahsan_61@yahoo.com	01712111195
2	Dr Shajahan Siraj	Senior Scientific Officer	Analytical & Environmental Chemistry, Micro sensor, ISO 17025:2005 Accreditation	shajahan.siraj.au@gmail.com	01942840438
3	Shamim Ahmed	Senior Scientific Officer	Analytical & Environmental Chemistry, Natural product chemistry, ISO 17025:2005 Accreditation	shamimchem@yahoo.com	01959906726
4	Muhammad Abdullah Al-Mansur	Senior Scientific Officer	Analytical & Environmental Chemistry, Natural products chemistry, ISO 17025:2005 Accreditation	nayeembcsir@gmail.com	01715010829
5	Shakila Akter	Senior Scientific Officer	Analytical & Environmental Chemistry, Natural product chemistry, ISO 17025:2005 Accreditation	shakilabcsir@yahoo.com	01913382006
6	Md. Ahedul Akbor	Senior Scientific Officer	Analytical & Environmental Chemistry, Natural product chemistry, ISO 17025:2005 Accreditation	akborbcsir@yahoo.com	01816188859
9	Md. Abu Bakar Siddique	Scientific Officer	Inorganic, Analytical, Environmental Nanochemistry and ISO/IEC 17025:2005 Accreditation	sagor.bcsir@gmail.com	01723454310

10	A.H.M Shofiul Islam Molla Jamal	Scientific Officer	Analytical , Environmental , Natural product chemistry, ISO 17025:2005 Accreditation	shofiuljamal@yahoo.com	01717258753
11	Md. Ripaj Uddin	Research Chemist	Analytical , Environmental , Pharmaceuticals Chemistry & ISO 17025:2005 Accreditation	md.ripajuddin@gmail.com	01737134073

List of Technical Personnel

1	A.K.M HABIBUR RAHMAN	JEO	hrahmanzhontuinars@yahoo.com	01911152118
2	Aftabuddin Ahmed	JEO	aftabard1961@yahoo.com	01911335513
3	Nur Nabi Chowdhury	Technician		01933180081
4	Khandakar Md. Abu Taleb	Junior Technician		01726427249
5	Ahmed Ali Islam	Lab. Technician		01718635031
6	Jahangir Alam	Sr. Lab Attendant	jahangirardbcsir@yahoo.com	01722930929

Personnel in Administration

1	Md. Abdul Gani Miah	Accounts Officer	Accounts	Gani.bcsir@gmail.com	01827313434
2	Md. Sikender Ali	Superintend	Office of the Administration		01817590675

Innovation team

Sl No.	Name	
1.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member Secretary
3.	A.H.M Shafiul Islam Mollah Jamal, SO, INARS, BCSIR, Dhaka.	Member

Tender opening committee

Sl No.	Name	
1.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Shakila Akter, SSO, INARS, BCSIR, Dhaka.	Member
3.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member Secretary
4.	Md. Nasir Uddin, SSO, Laboratory, BCSIR, Dhaka.	Member

Tender evaluation committee

Sl No.	Name	
1.	Director, INARS, BCSIR, Dhaka.	Convener
2.	Nominated Representative, Department of Chemistry, Dhaka University, Dhaka.	Member
3.	Nominated Representative, Department of Chemistry, BUET, Dhaka.	Member
4.	Md. Aminul Ahsan, PSO, INARS, BCSIR, Dhaka.	Member
5.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.	Member
6.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member
7.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member Secretary
8.	Abdul Gani Miah, Accounts Officer (Addl), INARS, BCSIR, Dhaka.	Member Secretary

Request for Quotation (RFQ) Process and direct purchase committee:

Sl No.	Name	
1.	Md. Aminul Ahsan, PSO, INARS, BCSIR, Dhaka.	Convener
2.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.	Member
3.	Abdul Gani Miah, Accounts Officer (Addl), INARS, BCSIR, Dhaka.	Member
4.	Shariar Bashar, SSO, IFRD, BCSIR, Dhaka.	Member
5.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member Secretary

Technical Sub-Committee:

Sl No.	Name	
1.	Shakila Akter, SSO, INARS, BCSIR, Dhaka.	Convener
2.	A.H.M Shafiul Islam Mollah Jamal, SO, INARS, BCSIR, Dhaka.	Member
3.	Md. Abu Bakar Siddique, SO, INARS, BCSIR, Dhaka.	Member Secretary

Estimated Price Verification Committee:

Sl No.	Name	
1.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Md. Ripaj Uddin, RC, INARS, BCSIR, Dhaka.	Member
3.	Md. Shakila Akter, SSO, INARS, BCSIR, Dhaka.	Member Secretary

Verification Committee:

Sl No.	Name	
1.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Mohammad Moniruzzaman, SSO, BCSIR Laboratory, Dhaka.	Member
3.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member Secretary

Annual Performance Agreement (APA)

Sl No.	Name	
1.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Md. Aminul Ahsan, PSO, INARS, BCSIR, Dhaka.	Member
3.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.	Member
4.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member
5.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.	Member
6.	Md. Shakila Akter, SSO, INARS, BCSIR, Dhaka.	Member
7.	Mohammad Majedul Haque, SO, INARS, BCSIR, Dhaka.	Member
8.	A.H.M Shafiul Islam Mollah Jamal, SO, INARS, BCSIR, Dhaka.	Member
9.	Md. Ripaj Uddin, RC, INARS, BCSIR, Dhaka.	Member
10.	Aftab Uddin Ahamad, JEO, INARS, BCSIR, Dhaka	Member
11.	A.K.M. Habibur Rhaman, JEO, INARS, BCSIR, Dhaka.	Member
12.	Md. Abu Bakar Siddique, SO, INARS, BCSIR, Dhaka.	Member Secretary

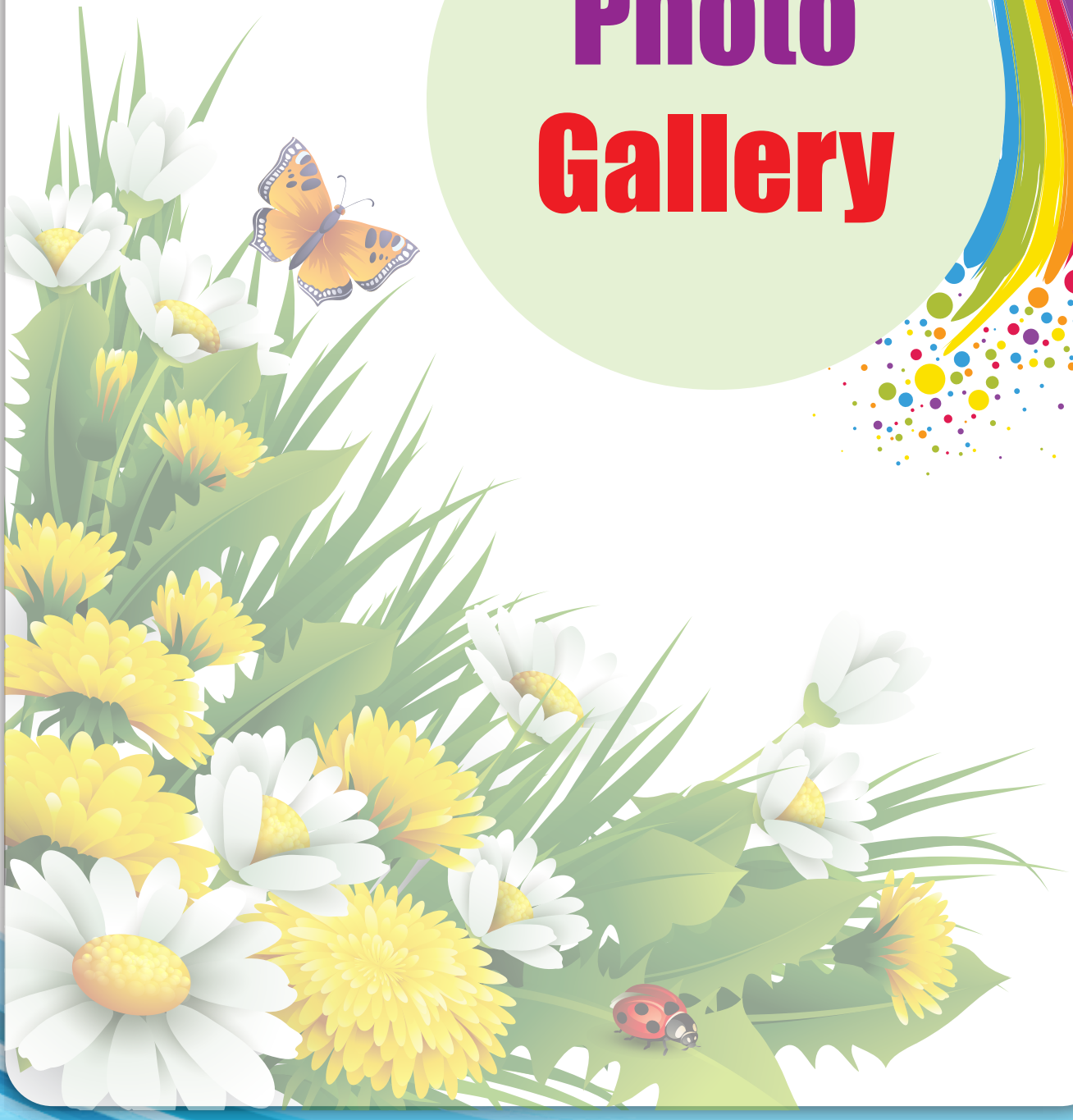
Annual Report:

Sl No.	Name	
1.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Convener
2.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.Dhaka.	Member
3.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member
4.	Md. Ripaj Uddin, RC, INARS, BCSIR, Dhaka.	Member
5.	Aftab Uddin Ahamad, JEO, INARS, BCSIR, Dhaka	Member
6.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member Secretary

Committee for Monitoring daily activities of INARS:

Sl No.	Name	
1.	Dr. Samina Ahmed, Director (in charge), INARS, BCSIR, Dhaka.	Convener
2.	Md. Aminul Ahsan, PSO, INARS, BCSIR, Dhaka.	Member
3.	Dr. Shajahan Siraj, SSO, INARS, BCSIR, Dhaka.Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member
4.	Shamim Ahmed, SSO, INARS, BCSIR, Dhaka.	Member
5.	Muhammad Abdullah Al-Mansur, SSO, INARS, BCSIR, Dhaka.Dhaka.	Member
6.	Md. Shakila Akter, SSO, INARS, BCSIR, Dhaka.	Member
7.	Md. Ahedul Akbar, SSO, INARS, BCSIR, Dhaka.	Member
8.	Aftab Uddin Ahamad, JEO, INARS, BCSIR, Dhaka	Member
9.	Md. Sikandor Ali, Admin, INARS, BCSIR, Dhaka.	Member Secretary

Photo Gallery




INARS


Intertek


ERNATIONAL CONFERENCE ON ENGINEERING MATERIALS AND
METALLURGICAL ENGINEERING
Materials for Energy, Environment, and Health
22-24 December, 201

THE END