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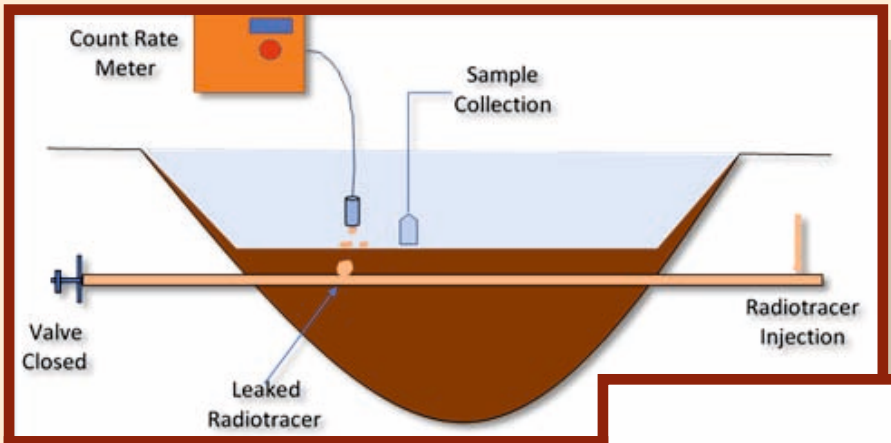
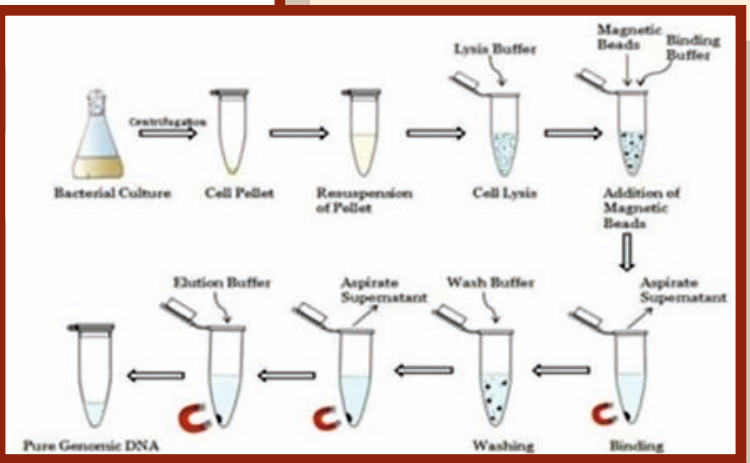
BRIT Bulletin

2024

Scientific Magazine



Leak detection using Radioisotopes



Genomic DNA extraction from bacterial cells using magnetizable cellulose

Schematic view of Low Temperature Irradiator

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY
BOARD OF RADIATION & ISOTOPE TECHNOLOGY

सत्यमेव जयते

ब्रिट बुलेटिन-2024

BRIT *Bulletin*- 2024

वैज्ञानिक पत्रिका
'Scientific Magazine'

विकिरण एवं आइसोटोप प्रौद्योगिकी बोर्ड, डीएई
Board of Radiation & Isotope Technology, DAE

GOVERNMENT OF INDIA

Front Cover : (a) Leakage detection using radiosotopes; (b) Genomic DNA extraction from bacterial cells using magnetizable cellulose; and (c) Schematic view of Low Temperature Irridator (LTI)

Back Cover : Logos of (a) ROTEX-1 “New Product Launch” by BRIT & (b) Central Government Schemes

प्रदीप मुखर्जी
मुख्य अधिकारी
Pradip Mukherjee
Chief Executive

सत्यमेव जयते
भारत सरकार
Government of India
परमाणु ऊर्जा विभाग
Department of Atomic Energy
विकिरण एवं आइसोटोप प्रौद्योगिकी बोर्ड
BOARD OF RADIATION & ISOTOPE TECHNOLOGY

राष्ट्र की सेवा में परमाणु
वि आ प्रौ बो
BRIT
ATOMS IN THE SERVICE OF THE NATION

Forward

In 2024, BRIT has completed 35 years of continuous operation as an independent entity and BRIT family has a lot to be proud of. I am happy to release the Publication of BRIT Bulletin-2024, which houses few of the many multidisciplinary research articles in scientific, engineering and technical fields.

BRIT Bulletin provides a forum for showcasing the research abilities and innovative ideas our scientists, technologists & engineers can pen down, that may be the substratum for paradigmatic shift in cognitive domain and deliver vital contribution to the greater human wisdom and welfare. As BRIT is focused on production and supply of products and devices which uses radioisotopes & radiation technology for varied applications, product innovation and/or product development, there is always a component of exciting opportunity for us to create something great together. In any applied R&D activity in a manufacturing unit, the aim is to develop technologies or improve existing product or production process that can be put to use in production for obtaining rugged products which are comparable to any international products. BRIT is the industrial arm of DAE, and the products or services thus resulted, also demands efficient validation & marketing to an array of customers.

We are constantly on the look-out to unlock the inherent strengths lying within our organization. Let's continue innovating, and please allow me to express my happiness to witness few of these being published in this Bulletin.

I am happy to present you all 'BRIT Bulletin-2024', the contents of which continues to give an insight of various R&D activities, technical communications & General articles, which are from diverse areas of science.

Dear Colleagues, I am confident, Team BRIT will continue providing your valuable contributions for upcoming BRIT Bulletin 2025, as well.

(Pradip Mukherjee)

From the Editor's Desk – Some Reflections

Warm greetings to the readers of BRIT Bulletin!

Board of Radiation & Isotope Technology (BRIT) is an industrial arm of Department of Atomic Energy (DAE). While producing & supplying a broad portfolio of products and services, based on radioisotopes & radiation technology in diverse fields of medicine, industry, research & agriculture, which remains the chief mandate of BRIT, it has also been continuously making efforts to upgrade the methodology/procedures, and are involved in bringing new products/services, which are customer-friendly. These newer developments or updation of the existing methods are carefully penned down to write various Scientific research/technical articles. Moreover, the General/Feature articles and Review articles that are exhibited in BRIT Bulletins, displays articles from diverse aspects of various fields of Science & Technology, for the viewers, who may or may not be of the relevant fields. In this way everyone gets a glimpse of each of the aspects of Science, and are growing academically. The new generation of Scientists & Engineers gets the hands-on experience and courage to read and write various types of articles.

Ten years ago, recognising the knowledge-driven nature of our Institution, the annual publication of the "BRIT Bulletin" was initiated. Comprising articles on the research & development, and/or updating the methods and/or procedures carried out in different Sections of BRIT, as well as General/Feature & Review articles, these Bulletins served as a forum for sharing professional insights, innovations and experiences. The maiden BRIT Bulletin was brought out during the Year 2015. Since then onwards, annually, BRIT has continuously seen its Publication.

The Editor has tried to keep up the spirits of the readers as well as the contributors of various articles throughout the decade. This BRIT Bulletin 2024 is the last of its kind, during my tenure, and I take up this opportunity to sincerely thank all the Scientists, Technologists & Engineers who have, and had, contributed generously their excellent articles to the Bulletins in all these years, making it a great success.

I also include my sincere gratitude to Chief Executive, BRIT, Shri Pradip Mukherjee, Dr. A.K. Kohli and Shri G. Ganesh, Ex-Chief Executives, BRIT, Shri Piyush Srivastava, Ex-SGM, Engineering & Corporate Planning, BRIT, and, Shri N. Jayachandran, GM, Labelled Compounds & Technical Services, BRIT, for not only entrusting faith & conviction in my idea of bringing out BRIT Bulletin, but also provided full support in making it a reality year after year.

I would also like to thank Shri Sathish Iyer, SO/F, along with past and present Heads of Public Awareness Division (PAD/DAE), for their continuous support for the Publications of the past and present Bulletins, by awarding through the printer appointed by DAE.

Here, I present BRIT Bulletin – 2024 before the learned readers!

Best Wishes and Happy Reading!

Dr. Tarveen Karir
Sr. Manager,
Scientific Information Resources & Publications (SIR&P)

CONTENTS

Brief Communication

Dosimetric Parameters Study of a Low-Temperature Irradiator

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Abstract

India is among the world's top producers and exporters of marine products (seafood). One significant challenge is ensuring the storage and transportation of these perishable items in optimal condition for export. The radiation processing using gamma radiation promises to maintain the quality of these high-value marine products by delivering a specific dose for a specific purpose. BRIT has set up a Low Temperature Irradiator at Vashi, Navi Mumbai which can be used to irradiate marine products. The irradiator is designed with 14.80 PBq of ^{60}Co sources arranged in cylindrical geometry. The product dimensions are chosen to achieve an acceptable dose uniformity ratio. The dose rates in the product, estimated with Monte Carlo simulations are found in good agreement with the measured values.

Introduction

Seafood is a rich source of protein for human consumption. India is one of the largest producers and exporters of marine products (seafood) in the world. One of the challenges faced is to store and transport this perishable food item in good condition for export. The quality is at risk due to the contamination of seafood with microorganisms responsible for food spoilage thereby opening a gateway to food-borne diseases to consumers[1]. The irradiation of seafood can significantly enhance the shelf life of fresh fish, eliminate pathogens in frozen fish, and control human parasite contamination in dried seafood. The marine products fall under Class IV of food products for radiation processing. The processing with gamma radiation promises to maintain the quality of these high-value quality of these high-value products by delivering a dose of 0.3 kGy to 7 kGy for elimination of pathogens, shelf-life extension, etc.[2]. BRIT has set up a Low Temperature Irradiator at Vashi, Navi Mumbai which can be used to irradiate marine products. The plant has a provision to supply blast air at -20°C during irradiation to maintain the cold chain. This paper discusses the dose mapping studies carried out on the irradiator.

Materials and Methods

The irradiator is designed for a maximum source strength of 14.80 PBq (400 kCi) of ^{60}Co. The source cage of the irradiator can accommodate 40 number of ^{60}Co source pencils (Type: BC-188) in a cylindrical arrangement. The cask with the source cage will sit in the concrete pit and the product will be moved down and up back from the irradiation position, as marked in Fig. 1. For initial operations, the irradiator is loaded with 3.54 PBq (95.72 kCi) in 16 source pencils. The sources, each having a different source strength, are loaded at specific locations such that the best dose uniformity is achieved for specific product dimensions[3].

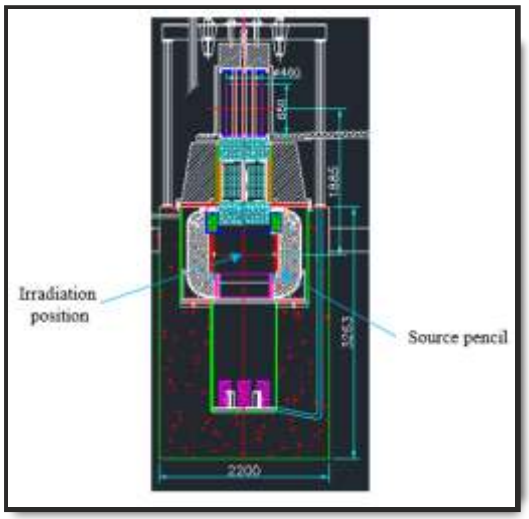

Fig. 1: Low temperature irradiator – AutoCAD drawing

- ***Optimization of Product Dimensions***

The geometry was modelled in Monte Carlo based FLUKA code[4] as per the given drawings. To get the best combination of dose rate and the DUR, the product box dimensions need to be optimized. These dosimetric parameters affect the efficiency of the irradiation plant. At first, 44 (L) x 42 (W) x 75 (H) cm was studied to cover the full tote box. The dummy product material was sawdust, in this case, with a bulk density of 0.22 g/cc. These evaluations are simulated for room temperature. After repeating the simulations for various product dimensions, 39.5 (L) x 39.5 (W) x 25 (H) cm was chosen for the study.

- ***Dosimeters Placement & Dose Rate Calculations***

The dose detectors are placed in three planes, viz., front, middle and rear with 15 positions per plane, as shown in Fig. 2 (a) & Fig. 2 (b). A number of dose points are needed to obtain the DUR which is the ratio of maximum dose to minimum dose. Similar dosimeter positions are chosen in experimental dosimetry to compare the results.

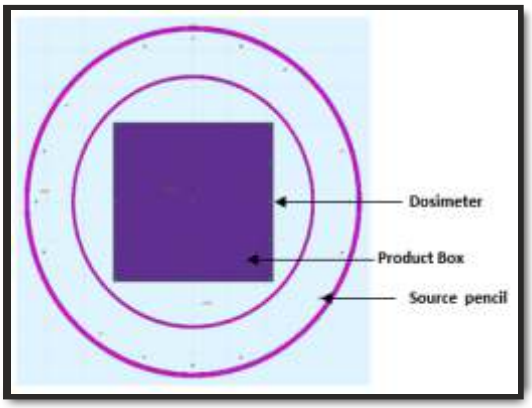

Fig. 2 (a): Simulation Model of Plan view (XY) of source- product geometry (Sawdust)

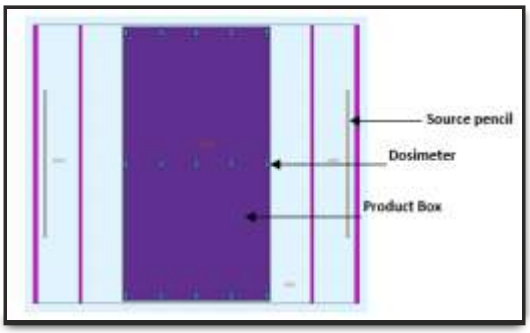

Fig. 2 (b): Simulation Model of Side view (YZ) of source-product geometry (Sawdust)

Theoretical calculations are carried out with water as the product material to match closely to the marine products. The number of histories used in the simulations is 6E06 to obtain the statistical errors below 5%. The experimental dosimetry is carried out with water pouches, the bulk density achieved as 0.70 g/cc. The dosimetric solution used is ceric-cerous sulphate which has an absorbed dose range between 0.5 and 50 kGy. The dosimeters in water are modeled and are shown in Fig. 3 (a) & Fig. 3 (b). The density for theoretical estimations is chosen as that of the experiment, to compare the results.

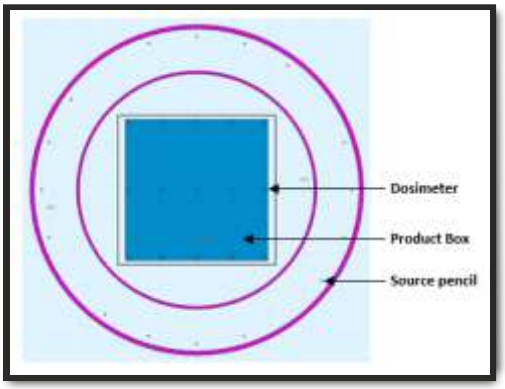

Fig. 3 (a): Simulation Model of Plan view (XY) of source- product geometry (Water)

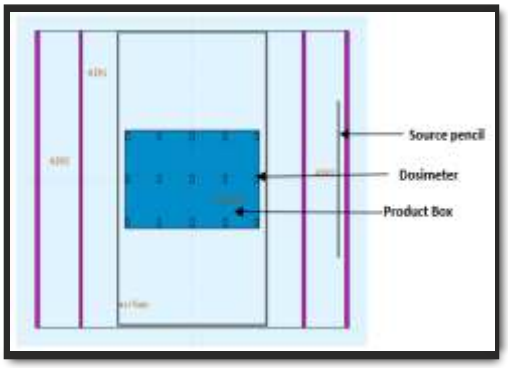

Fig. 3 (b): Simulation Model of Side view (YZ) of source-product geometry (Water)

Results and Discussion

The calculated dose rates are used to calculate the DUR which is an important parameter for a food irradiator to run efficiently. The first case study with the dummy product as sawdust, the theotrical and experimental results showed a DUR of 2.96. The results of the repeated study with water are shown in Table I.

The average dose rate is important for calculating the product residence time in radiation field while the DUR influences the efficiency of the irradiator. The average dose rate and DUR are presented in Table II. Although the individual dose rates varied within 1–18 % when compared with dosimetry results, the average dose rate obtained with theoretical simulations matched within 6% of the experimental data. The theoretical DUR in this case is improved to 1.97. The theoretical DUR varied by 3.02 %. The variations may be due to statistical nature of the method itself, the number of histories run, the Physics settings chosen, etc. The average dose rate is important for calculating the product residence time in the radiation field while the DUR influences the efficiency of the irradiator.

Table I: Dose rates in water (for bulk density, 0.7 g/cc)

Front plane		Middle plane		Rear plane	
Dose rate (kGy/h)		Dose rate (kGy/h)		Dose rate (kGy/h)	
Expt	Theo	Expt	Theo	Expt	Theo
5.22	4.89	3.56	4.00	4.98	4.76
4.83	4.42	3.05	3.01	4.45	4.15
4.39	3.88	3.01	2.82	4.10	4.00
4.54	4.15	3.13	2.99	4.41	4.02
5.17	4.85	3.65	4.07	4.93	4.81
5.74	5.46	4.04	4.51	5.78	5.29
5.08	4.68	3.32	3.45	5.35	4.63
4.84	4.42	3.21	3.07	4.79	4.49
5.02	4.49	3.42	3.36	4.97	4.57
5.64	5.51	3.98	4.32	5.38	5.44
5.42	4.97	3.85	4.26	5.77	5.03
5.00	4.29	3.16	3.00	4.91	4.26
4.77	4.14	3.06	2.79	4.59	3.87
4.93	4.00	3.13	2.97	4.90	4.21
5.59	4.76	3.13	4.21	5.20	4.74

Table II : Comparison of Average dose rate and DUR in water (for bulk density, 0.7 g/cc)

Dosimetric parameter	Theoretical	Experimental
Average Dose Rate (kGy/h)	4.22	4.48
D_{max} (kGy/h)	5.51	5.78
D_{min} (kGy/h)	2.79	3.01
DUR	1.98	1.92

Conclusion

The dosimetric study shows that the low-temperature Irradiator can be utilized for seafood irradiation and the Monte Carlo simulations can be used as a guiding tool to understand the dose distribution of new design of an irradiator. The methodological approach of an optimized irradiation process ensures the dose uniformity and plant efficiency, ultimately enhancing the quality and safety of the irradiated marine products.

References

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2. Atomic Energy Publication "Radiation Processing of Food and Allied Products" **(2012).**
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Original Research Article

A Convenient Procedure for the Preparation of [^{14}C]-Planchet Sources

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Abstract

This paper describes a convenient method for the preparation of [^{14}C]-planchet sources. In this method a solution of [7-^{14}C]-benzoic acid and the epoxy polymer in acetone: dry ethanol (1:1 v/v) is deposited on the surface of a stainless steel or aluminum planchets of size 25mm diameter and 2mm height. Once the polymerization and drying process is completed, a thin layer of polymer of less than 2 mm thickness is formed on the surface of a planchet. 2 π emission rate of beta particles from the specified geometry of the [^{14}C]-planchet source is certified by GM counter with repeated counting. Surface contamination test of [^{14}C]-planchet source was carried out by swipe test followed by counting in liquid scintillation analyzer. This thin film deposition method is rapid, cheaper and less labor intensive.

Introduction

Particulate matter concentration in air is a matter of concern as it is associated with adverse health effects on respiratory and cardiovascular systems. Automatic air activity sampler is a device used to measure online aerosol mass concentration. Various types of instrument-based techniques such as gravimetric mass determination[1,2], optical light scattering[3,4], and radiometry[5,6,7], are available for measuring the particulate matters.

Beta gauge devices, based on attenuation of beta particles, is the most widely used real-time technique in air quality monitoring system using the instrument such as Durag Verewa F-701-20 for the measurement of aerosol mass.

for the measurement of aerosol mass. This instrument is commercially available worldwide. Beta gauge system consists of beta particle source, a detector and a suitable filter with a holder. Mass collected on the filter is determined by measuring the relative change in beta particle count rate before and after passing aerosol through the filter. Stainless steel or aluminum planchet coated with a thin film of polymer containing 100 μCi of C-14 activity is used for this purpose and a calibration curve is generated to relate attenuated intensity and mass collected on filter media. Carbon-14 is a pure beta particle emitter having a half-life 5730 years. Its long half-life makes it an isotope of choice to use as a source of beta particles which does not require decay corrections over the duration of measurement.

Experimental

Materials

In-house [7-^{14}C]-benzoic acid was prepared[8] by Grignard method and used in the preparation of [^{14}C]-Planchets. Polymers such as polymethyl methacrylate (PMMA), polystyrene (PS), polyvinyl pyrrolidone (PVP) were procured from indigenous sources. All other chemicals used were of analytical grade and purchased from S.D. Fine-chemicals. Epoxy polymer used was of Araldite Standard (epoxy polymer was available in two separate packs such as epoxy resin plus hardener). Stainless steel planchets and aluminum planchets (25 mm OD x 2 mm H, active diameter: 22 mm) were obtained from indigenous sources.Radioactivity of the liquid samples and swipe samples were analyzed in Hidex make 300 SL TDR liquid scintillation analyzer. [^{14}C]-Planchets were counted under calibrated EECIPL GM counting assembly.

Methods

a) Preparation of 100 µCi [^{14}C]-stainless steel planchet

One side of a stainless steel planchet of size 25 mm OD x 2mm H (active diameter 22 mm) was first rubbed with sand paper to obtain a rough surface suitable to hold thin film of polymer. The rough surface was first cleaned with acetone and then under the stream of air.

The planchet was weighed twice, i.e. before and after the polymer coating. Two drops each of resin and hardener (total weight 1.1 gm) mixed well in the ratio of 1.25: 1 (v/v) in a 20 mL capacity glass-vial. 2 mL solution of acetone and dry ethanol (1 :1 v/v) was added in the above vial and prepared an epoxy polymer solution. 400 µL of the prepared epoxy polymer solution was transferred to an Eppendorf vial and added a 100 µL solution of [7-^{14}C]-benzoic acid (100 µCi) in a solution of acetone and dry ethanol (1 :1 v/v) and mixed well.

Stainless steel planchet was arranged in a horizontal position and 500 µL of the prepared radioactive epoxy polymer solution was discharged drop by drop in the middle of inscribed circle of the planchet with the help of micropipette. The solution was allowed to spread for uniform lateral distribution. After the addition of complete solution, the planchet was covered with inverted petri dish and kept at room temperature for 5 hours. Due to slow evaporation of solvent a thin, uniform and transparent film of polymer formed on the surface of the planchet. The planchet was further dried in a desiccator over calcium chloride by keeping it overnight and then weighed.

Contents in the Eppendorf vial were dissolved in 1 mL solution of acetone and dry ethanol (1:1 v/v). It was assayed for left-over radioactivity to know the exact amount of radioactivity used for the preparation of [^{14}C]-planchet and found to be less than 0.3 %.

b) Test for surface contamination of [^{14}C]-planchet source

Whole of the external surface of the [^{14}C]-planchet source was thoroughly wiped with a swab of filter paper moistened with water so as to effectively remove any loose radioactivity associated with the film. After radioactivity assay of the swab by liquid scintillation analyzer the counts obtained was found to be 59 Bq. According to the acceptance criteria, the [^{14}C]-planchet source thus prepared is said to be free from surface contamination as the detected radioactivity has the counts less than 185 Bq.

c) 2 π beta emission rate of [^{14}C]-planchet source

Beta count of the [^{14}C]-planchet source film surface was taken at a specified repeatable counting geometry. [^{14}C]-planchet was counted using NIST traceable carbon-14 standard planchet at a distance of 1 cm from the surface with calibrated EECIPL GM counting assembly (0.836 % efficiency). The count rate of prepared [^{14}C]-planchet was found to be 745000 cpm with a counting efficiency 0.412%.

Results and Discussion

Most important component in the preparation of [^{14}C]-planchet source is the solvent which must be compatible with C-14 source and also with the polymer. The success of [^{14}C]-planchet source preparation depends on the quality of the thin film formed when the solution of polymer and C-14 source in a suitable solvent is evaporated from the planchet surface. The physical appearance of the thin film formed on the planchet surface should be homogenous and uniform throughout so that carbon-14 source is to spread uniformly across the surface. **Homogeneity, uniformity and smoothness have an impact on the counting.** A detector may not count correctly if one part of the thin film is different from the rest of the part.

Our next goal was to select a suitable solvent and a polymer. The proposed solvents included ethyl acetate, Tetrahydrofuran (THF), ethanol, methanol and acetone. The polymers that were chosen included solids such as polymethyl methacrylate (PMMA), polystyrene (PS), polyvinyl pyrrolidone (PVP) and liquids such as epoxy polymer (EP). Epoxy polymer is available in two-part form as flowable liquids

Table 1. Comparison between the Solubility of Polymers in various Solvents

Polymer	Acetone	Methanol	Dry Ethanol	THF	Ethyl acetate	Acetone: Dry Ethanol (1:1v/v)
PVP	**Soluble**	Soluble	Soluble	**Soluble**	Soluble	**Soluble**
PMMA	**Soluble**	Insoluble	Insoluble	**Soluble**	Insoluble	**Soluble**
PS	**Soluble**	Insoluble	Insoluble	**Soluble**	Insoluble	**Soluble**
EP	**Soluble**	Insoluble	Soluble	**Soluble**	Insoluble	**Soluble**

consists of an epoxy resin and hardener. Several tests were conducted to determine solubility of the polymers in the organic solvents. One gram each of PS, PVP, EP, PMMA were placed in individual solvents, viz., ethyl acetate, methanol, dry ethanol, THF and acetone to check the best one.

The mixture was kept overnight for dissolution in these solvents. Ethyl acetate, methanol and dry ethanol did not dissolve the polymers. The polymers that dissolved in THF were PMMA and polystyrene. Epoxy polymer dissolved quickly in acetone and to the lesser extent in dry ethanol. Results are shown in Table-1.

In the beginning itself it was ensured that the bottom of the planchet is flat. During the process, the planchet was kept perfectly horizontal in a fume hood, so that there is an even distribution of solution. In order to make a thin film of polymer containing benzoic acid, the prepared solution was gradually discharged drop by drop in the middle of the inscribed circle of the planchet using a transfer pipette. The solution was allowed to spread for uniform lateral distribution onto the planchet surface and then kept for 5 hrs. at room temperature. A thin film of polymer was formed on the planchet surface after complete evaporation of solvent. Further, overnight drying of polymer was carried out by keeping the planchet in a desiccator over calcium chloride.

The results of the different thin film formulation studies are shown in Fig.1 & Fig.2. From Fig.1 it was evident that when the polymers such as PVP & PMMA were used in combination with various solvents other than acetone-dry ethanol mixture (1:1v/v), the films formed were either non-homogenous or non-uniform. In case of PMMA the thin film did not adhere to the stainless-steel surface, while PVP thin film had ripples. It was evident that **combination of epoxy polymer and acetone-dry ethanol mixture (1:1 v/v) as solvent worked effectively to create a thin film**, as it did not flake after drying as well as dissolved when water was put on the film surface. **The polymer thin films containing C-14 benzoic acid and epoxy polymer adhered to the planchet without breaking into pieces and were used for subsequent testing.**

Fig. 1: Planchets with different polymers, EP- epoxy polymer, PMMA- Polymethylmethacrylate, PVP- Polyvinyl pyrrolidone

Fig. 2: [^{14}C]-Planchets prepared with the epoxy polymer

Acetone used in the preparation has two roles: [a] to dissolve benzoic acid and epoxy polymer, and, [b] as a vaporizable wetting agent. Acetone makes the contents to dry at lower temperature i.e. 24^{0}C and avoid solution to splatter. The wetting agent also prevents uneven distribution of the solid over the inner layer of planchet. **The combination of acetone & dry ethanol (1:1 v/v) gave a clear transparent solution of polymer and benzoic acid.**

The ratio of concentration of the resin to the hardener in the epoxy polymer was between 1.2: 1 to 1.6: 1 (w/w), while the same for the epoxy polymer to solvent - acetone: dry ethanol (1:1 v/v), was 1:7 to 1:9 (w/v).

Preparation of C-14 Planchets

Fig. 2 shows different C-14 planchets prepared using varying concentration of C-14- benzoic acid ranging from 0.1 µCi to 100 µCi and **200** mg of epoxy polymer solution in acetone: dry ethanol (1:1 v/v).

This study was undertaken to determine the dependency of C-14 benzoic acid concentration on the counting efficiency of the instrument and also to find out the uniformity of the lateral distribution of radioactivity in a thin film. Experimental results are tabulated in Table 2.

The uniformity of the lateral distribution of radioactive thin film was checked with a GM counter of a fixed geometry and having a shield of perforation. The planchet was gradually moved in to the detection area of the GM counter to enable the radiations from different zones to be seen by the counter, in order to determine the significant variation in the surface count rate of the thin film. Since the count rate was uniform, an average count was taken under a specified geometry. The counts were corrected for background by counting a thin film, which had been prepared in a similar manner by employing non-radioactive benzoic acid.

Table 2. Counting rates of C-14 in EP thin films

Planchets	Activity (µCi)	Weight of the film (mg)	Counts on the film			
			Observed CPM in different zones	Average CPM	DPM	Efficiency of the counter for [^{14}C]-planchets
01	0.1	196	784 734 769	762	873	0.393
02	0.5	184	4743 4819 4858	4807	5712	0.515
03	1	181	9433 9485 9327	9415	11224	0.506
04	2	189	14640 14990 15130	14920	17809	0.401
05	5	188	44060 43860 44120	44010	52605	0.474
06	10	184	130900 131300 130800	131000	156660	0.706
07	20	145	235600 231600 232900	233400	279148	0.629
08	100	160	748600 749000 747800	748500	895297	0.403
09	100	176	745000	745000	891148	0.401
10	Without radioactivity (Background)	33 28 35	32	---	---	---

- **Efficiency of the counter for standard C-14 source = 0.836 %**
- **Background counts for thin film = 32 cpm**
- **Average weight of thin films on planchets = 172 mg**
- **Aluminum planchets – 1 to 7 and stainless steel planchets – 8 and 9**

Average efficiency of the counter was fairly constant between 0.4 to 0.5 % for counting 100 µCi [^{14}C]-planchets and is independent of the absolute activity in the film. Exception being the planchets prepared with 10 & 20 µCi carbon-14 radioactivity of similar polymer thickness. Average counting efficiency of the counter for these planchets was found to be maximum (0.668%). After two years, the prepared 100µCi planchets were checked for physical appearance and 2 π beta emission rate. **It was observed that even after two years, the coated thin film of planchet was found to be unaltered with a constant 2 π beta emission rate.**

Conclusion

In the technique, described in this paper, for the production of [^{14}C]-planchet source, several polymers and solvents were tried for the optimization of the preparation of thin films of various thicknesses and validated. The thin film of thickness, less than 2mm, thus prepared by using the epoxy polymer and [^{14}C]-benzoic acid in acetone: dry ethanol (1:1 v/v) solution was found to be the most suitable one for the production of [^{14}C]-planchet sources. The materials used for the planchet preparation are minimal in quantities, cheaper and readily available. The procedure of preparation is faster, simpler and less labor-intensive. Coated film and radioactivity associated with these [^{14}C]-planchets, thus prepared, were found to be stable even after 24 months.

Acknowledgment

The authors sincerely thanks Shri Pradip Mukherjee, Chief Executive, BRIT for his support in the work and Shri Amit Chindarkar, HP/RSSD, BARC for his assistance in the counting of the planchets.

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Original Research Article

Integrity Assessment of Underground Underwater Pipeline using Radiotracer Technique

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Abstract

The energy sources such as oil and gas are transported through underground pipelines. This is the most economical and safest mode of transportation. Leakage is one of the main causes of heavy product losses. It disturbs the normal operation of the pipeline, pollutes the environment, and threatens personal safety. Corrosion of pipelines transporting oil and gas resources leads to product leakage and affects the economy. Other significant causes for pipeline leaks are damage by excavation equipment, accidents, theft, earth movement, etc.

There are many available technologies in the field of leak detection of underground pipelines such as fiber optic cable, sensor hoses, acoustic sensors, smart pigging, pressure point method, RTTM-based system, etc. Radiotracer techniques are very helpful in the leak detection of long underground pipelines due to their high sensitivity and accuracy. A suitable radiotracer is injected into the pipeline and detection of the leaked radiotracer is performed from the ground surface, by placing the detectors in dug pits or by launching a PIG equipped with data logger. Tracer patch migration, velocity drop, and detector-PIG are a few of the methods to detect and locate the leak in underground pipelines.

In a cross-country product pipeline of a leading refinery of India, leakage was suspected in the section located below the river bed. A very small amount of compatible radioisotope was injected as a radiotracer into the pipeline to test its integrity. The outlet valve located downstream was closed to pressurize the pipeline. It was planned to detect the leaked radiotracer by radiation survey of the water body as well as sample analysis in the laboratory. This paper presents the case study on the leak detection method of buried pipelines under a water body including outcomes and benefits to the refinery.

Introduction

Radiotracer technique is playing an important role in industry. It is used to diagnose specific causes of malfunctions in a plant or process operation and to generally investigate processes in industries and those related environments where a great cost-benefit ratio can be generated from process optimization and troubleshooting, such as leakage detection in underground pipelines, Identification of leaky heat exchanger, transport of sediments etc.[1-4]. It is expected that this important role will continue to expand in India, especially if refinery engineers will get aware about these activities.

Major advantage of radiotracer study is its utility without disturbing the process i.e., it is carried out online. Conventional methods of troubleshooting like pressure drop studies, viscosity measurements, sampling etc. can provide rough idea about the problem in the system but they cannot pinpoint the problem area [5]. Whereas, tracer applications are widely used for effective trouble shooting and to arrive at exact problem location. These methods require trained manpower, additional training for handling of radioisotopes and knowledge of radiation safety.

A significant number of underground pipelines are installed for the transportation of water, oil, and gas. Leakage within these pipelines not only reduces their transport capacity but also results in significant environmental pollution. The detection of leaks in buried pipelines presents a

considerable challenge due to limited access. The radiotracer method has demonstrated effectiveness in locating leaks within such pipelines.

Radiotracer techniques offer significant advantages in detecting underground pipe leaks due to their superior sensitivity and accuracy compared to conventional NDT methods. The process involves injecting a suitable radiotracer into the pipeline and applying specific pressure to facilitate potential tracer leakage. If leakage occurs, the tracer may migrate towards the ground surface or become adsorbed on the soil or thermal insulation surrounding the leak point. Leak detection is achieved by surveying the radioactivity emitted by the leaked radiotracer[2,6,7].

Bharat Petroleum Corporation Limited (BPCL) Mumbai, suspected leakage in their cross-country pipeline (Mumbai-Manmad) situated beneath the Ulhas River (Gandhari Bridge-Kalyan) between their sectionalizing valve stations (SV-3 & SV-4). Oil bubbles were observed on the surface of the water body. As this pipeline was the sole available option with no viable alternatives, it was imperative to verify the integrity of the pipeline. Any leakage would necessitate labor-intensive and costly repair procedures. Therefore, it was decided to conduct an integrity assessment of this pipeline using a radioactive isotope-based survey.

In response to this novel challenge, an experimental plan was devised utilizing the radiotracer technique, which was subsequently implemented successfully to evaluate the pipeline's integrity.

Experimental

(a) Pipeline details: The particulars of the pipeline under investigation are delineated in Table 1, while the layout is depicted in Figure 1.

Table 1: Particulars of the Pipeline under Investigation

Length & diameter of the pipeline under study	650 m under river bed / 18 inch
Operating flow rate	Max. 1200 kL/h Min. 600 kL/h
Operating Pressure	Max. 47 kg/cm^2 Min. 32 kg/cm^2
Nearest Injection Point	Mumbai dispatch terminal (50 Kms)
Arrival time	6.45 hrs. with max. flow rate

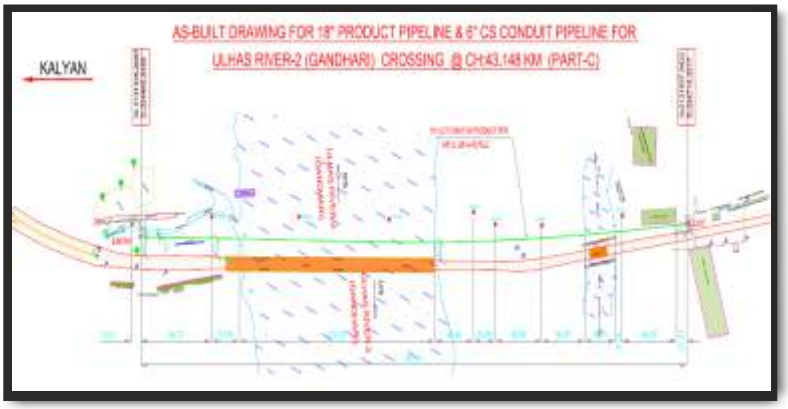

Fig. 1: Schematic view of pipeline located under Gandhari River

(b) Methodology

Fig. 2 states the principle of radiotracer method for leak detection in buried pipeline under the river bed. A very small amount of a compatible raadioisotope was injected as a radiotracer into the pipeline. The outlet valve at the downstream was closed to pressurize the pipeline. The leaked radiotracer can be identified by underwater radiation survey of the surrounding area in the river as well as sample analysis in the laboratory.

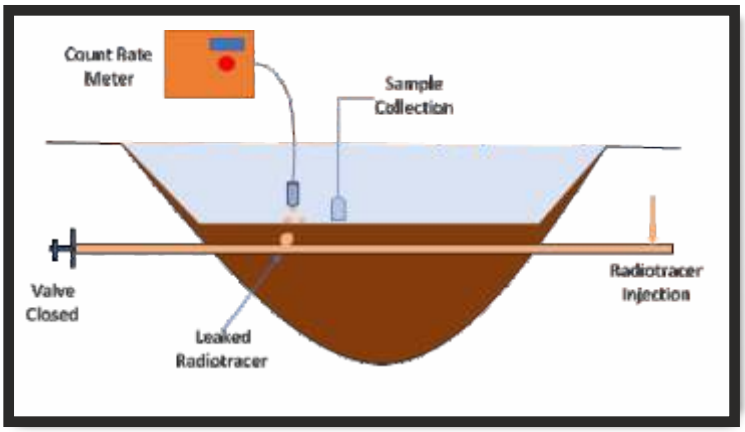

Fig. 2: Leak detection principle by radiotracer method

(c) Job Execution

Considering the urgency of the job, prompt response was taken to conduct the radiotracer study. It was decided to carry out the radiotracer study by injecting 2 Ci of Mo-99 (half life: 66 hrs & gamma energy: 760 keV) as organic sodium molybdate[8]. Around 21:00 pm, radiotracer was injected into the pipeline through chemical dosing pump at Mumbai Dispatch Terminal (MDT). Entry of the radiotracer into the pipeline was confirmed through RadEye survey meter (SN 31477). The radiotracer was expected to arrive near the bridge in 6.45 hrs. after injection from the terminal. The passage of the radiotracer through SV-3 (near bridge) was confirmed around 04:00 am. After confirmation, SV-4 was closed and pipeline was pressurized up to 40 kg/cm^2 to allow maximum possible flow of radiotracer through leakage. For confirmation of leak, radiation survey of the water body through underwater radiation monitoring system was started around 06:00 am. Readings were recorded at different strategic locations along the bridge. Total 14 nos. of water samples were collected from multiple locations of the river. The samples were sent to Radio Analytical Laboratory (RAL), BRIT for its analysis to verify the presence of injected radioactive isotope.

Fig. 3: BRIT team performing radiotracer injection at MDT

Fig. 4: Confirmation of radiotracer passage at SV-3

Fig. 5: Survey area of Ulhas River, Gandhari Bridge

Fig. 6: Underwater radiation monitoring system (left) and water sampler unit (right)

Fig. 7: Water bubbles observed during radiation survey in the river

Fig. 8: BRIT & BPCL team after successful radiation survey

Fig. 9: Sample analysis setup at RAL, BRIT-Vashi

(d) Safety Issues

Radiotracer used for leakage detection in this study was Mo-99 as sodium molybdate in organic phase. This is having gamma energy of 760 KeV and half-life of 66 hrs. Total activity used for this study was around 2 Ci (74 Gbq). This activity is not as hazardous as the intensity of a radiography sources which is usually more than 10 Ci (370 GBq). In case of radiography being carried out, the surrounding area needs to be cordoned off.

In general, criteria of time, distance and shielding needs to be observed while handling radioisotopes. Time taken to handle the radioisotope or when in vicinity should be minimum, the radioisotope should be handled from a distance as far as possible or one should keep away from the source and the radioisotope needs to be adequately shielded for handling i.e., surface dose rate on the transport container should be less than 200 mR/hr.[9].

All these factors were strictly taken into account while carrying out the radiotracer injection and it was carried out by trained and experienced professionals from BRIT by following the principles of ALARA (As Low as Reasonably Achievable).

All the radiation safety PPEs were used such as gloves, mask, tongs, TLD etc. while injection and safety jacket during radiation survey in the river. It was assured that general public / plant staff and workers do not get in the vicinity of the radioactivity except those involved in the direct handling.

Results & Discussion

After the injection of a radiotracer and pressurization of the pipeline, two distinct criteria were implemented to verify the existence of a leak. Firstly, any increase in radiation levels surpassing background readings in underwater areas adjacent to the pipeline was monitored. Secondly, detection of the injected radioisotope Mo-99 or its daughter element Tc-99m within water samples, collected from the river. Concurrently, oil bubbles observed on the water surface during radiation survey were collected and examined in the laboratory to confirm the presence of radioisotopes.

The underwater radiation monitoring system comprised of a waterproof sodium iodide scintillation detector, which was connected via a 100-meter-long cable spool to a count rate meter. A boat was used to reach at different locations in the river. A background survey conducted on the river revealed a count rate ranging between 80 to 100 counts per minute (cpm). Additionally, a sampling procedure was executed to collect water samples before radiotracer injection, facilitating background counting in the laboratory.

Throughout the radiation survey, the scintillation detector consistently recorded counts between 80 and 100 counts per minute (cpm) as it was submerged in the river water, indicative of background radiation levels. This trend persisted even upon the detector making contact with the river bed. It was observed that oil bubbles were appearing near first pillar of the bridge from SV-3 location. This area was surveyed carefully. However, no significant rise from the background radiation level was observed at any of the location in the Ulhas River.

Conversely, water samples were marked carefully and immediately subjected to analysis using a high-purity germanium (HPGe) detector to detect the injected radioisotope Mo-99 (energy: 760 keV) and its decay product. Tc-99m (energy: 140 keV)[10]. However, no peak of Mo-99/Tc-99m was detected in the water samples. Sample analysis results are shown in the Annexure-I.

Conclusion

Radiotracer study was successfully conducted to assess the integrity of a 650-meter long pipeline segment located beneath the Ulhas River near Gandhari Bridge in Kalyan. The study confirmed that the pipeline was intact. The presence of oil bubbles in the river was attributed to potential leaks from another pipeline or other unidentified sources. The radiotracer study enabled rapid results without disrupting production, avoiding labor-intensive procedures and the high costs associated with a shutdown for leak confirmation. As a result, the pipeline remained in continuous operation.

Acknowledgments

We extend our sincere thanks to the BPCL authorities for their trust in our technology and for providing commendable support and facilities during the radiotracer study. We acknowledge the efforts of the Manager (FMF & Mo-99 Generators) and General Manager (RPL & FMF) for the timely supply of radiotracers, as well as the General Manager (LC & TS) for the prompt analysis of samples. We also appreciate the support of the Manager (REPF Workshop) for providing the necessary manpower. Additionally, we express our gratitude to the General Manager, ESSA, and the Chief Executive of the Board of Radiation and Isotope Technology (BRIT) for their encouragement and consultation regarding our projects and activities.

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Annexure - I

Regions of interest

Sample identification: IAS B3, B4, B5, 1000 SEC , 21052023
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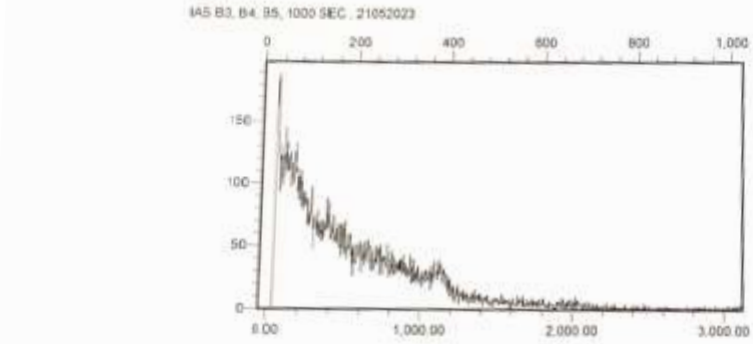

RoI number	Left margin [channels]	Left margin [keV]	Right margin [channels]	Right margin [keV]	Centroid [keV]	Grosscounts	Netcounts
1	212	609.90	241	699.73	651.13	1196.00	151.59
2	465	1393.64	507	1523.75	1455.30	289.00	0.00
3	264	770.98	279	817.45	790.42	566.00	47.00

Regions of interest

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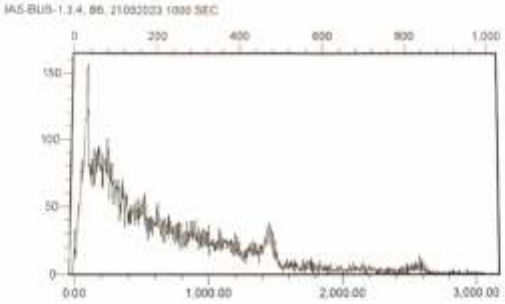

RoI number	Left margin [channels]	Left margin [keV]	Right margin [channels]	Right margin [keV]	Centroid [keV]	Grosscounts	Netcounts
1	208	614.83	232	690.18	647.87	882.00	0.00
2	263	787.51	270	809.48	796.53	197.00	43.40
3	463	1415.41	491	1503.31	1446.17	710.00	481.56

Regions of interest

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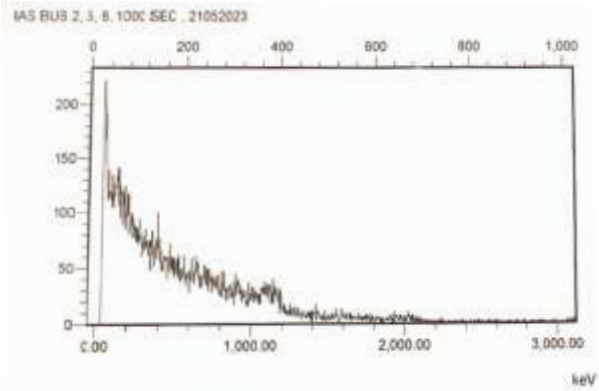

RoI number	Left margin [channels]	Left margin [keV]	Right margin [channels]	Right margin [keV]	Centroid [keV]	Grosscounts	Netcounts
1	212	609.90	241	699.73	652.81	1283.00	157.40
2	465	1393.64	507	1523.75	1454.24	276.00	0.00
3	264	770.98	279	817.45	790.76	537.00	0.00

Regions of interest

Sample identification: ias- A1, B1, B2, A1a 21052023,1000 sec
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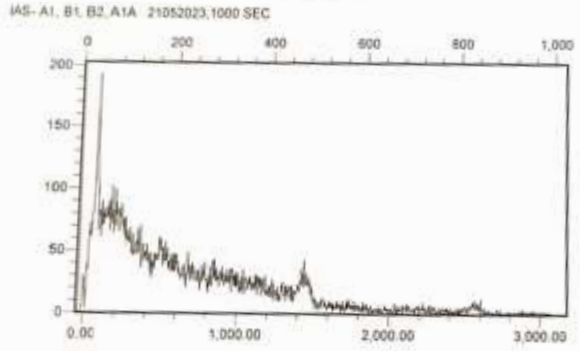

RoI number	Left margin [channels]	Left margin [keV]	Right margin [channels]	Right margin [keV]	Centroid [keV]	Grosscounts	Netcounts
1	208	614.83	232	690.18	648.74	822.00	0.00
2	263	787.51	270	809.48	796.17	203.00	36.80
3	483	1415.41	491	1503.31	1442.23	677.00	451.66

Original Research Article

Development of Genomic DNA Extraction Method from *bacterial cells* using Magnetizable Cellulose and it's Comparison Study with Spin Column-based Genomic DNA Extraction Kit

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Abstract

A method was developed to extract Nucleic acid using magnetizable cellulose particles from bacterial cells and its performance was compared with the spin column separation method. The Nucleic acid extracted using magnetizable cellulose particles can be used for all downstream applications like PCR, qPCR. Magnetic particles method gave high molecular weight DNA compared to that of spin column method with better yield.

Introduction

The extraction of biomolecules, DNA, RNA, and protein, is the most crucial method used in molecular biology[1]. It is the starting point for downstream processes and product development including diagnostic kits. DNA, RNA, and protein can be isolated from any biological material such as living or conserved tissues, cells, Bacterial cells[1]. Nucleic acid purification had been a time and work consuming process using organic solvents, often limited by low yields and purity, and not suited for automation and scaling. Magnetic separation of nucleic acids is user and environmentally friendly technique which uses the super paramagnetic particles to separate nucleic acids easily after their binding on their functional surface. This is a quick and efficient way to separate Nucleic acids without any rigorous centrifugation, that generates shear forces which may lead to the degradation of Nucleic acids. The process can be automated and scaled up easily.

Magnetic separation

The use of magnetic particles in separating the bio molecules gaining importance because of its many advantages compared to the traditional methods. Magnetic properties of materials are size dependent. As the size decreases, at a specific critical diameter the material shows Super paramagnetic behaviour. Super paramagnetic behaviour is the combination of Para and Ferro magnetic behaviour. We need super Para magnetic particles for magnetic separation of nucleic acids because the particles have to exhibit large magnetic moments in the presence of external magnetic field to separate them easily after binding to bio-molecules and zero magnetic moment in the absence of external magnetic field to disperse them in the solution[2].

Magnetic nano and microparticles used for Nucleic acid separation consist of Magnetic core, and surface coating. Magnetic core generally iron based oxides because of their high saturation magnetization values, stability under oxidizing conditions and limited toxicity. Surface coating on Magnetic particles plays an important role to make them functional for specific binding of Nucleic acids and to prevent agglomeration of particles.

Magnetizable Cellulose

Cellulose is a renewable glucose biopolymer, found in plant cell walls. Particles which contained magnetic properties are encapsulated in cellulose to form magnetizable cellulose. The magnetizable core facilitates the separation of the magnetizable cellulose under magnetic field

while the cellulose affords a convenient matrix for binding of bio molecules. Nucleic acids bind to the magnetizable cellulose in the presence of high salt and polyalkylene glycol concentration[3]. When PEG [H-(O-CH_2-CH_2)$_n$-OH] is added to a DNA solution in saturating condition, DNA forms large random coils. Adding the right concentration of salt (Na+) causes DNA to aggregate and precipitate out of solution.

Materials and Methods

Materials and reagents

Tryptone & Yeast extract were purchased from HiMedia, Tris base, Concentrated Hydrochloric acid, Triton X 100, EDTA disodium dihydrate, Guanidine hydrochloride, Sodium chloride, Potassium chloride, Disodium hydrogen phosphate di hydrate, Potassium dihydrogen phosphate, Lysozyme, Proteinase K, RNase A & Acetone were purchased from Sigma-Aldrich, PEG-8000 was purchased from Promega, Spin Columns were procured from Epoch Life Science, Nuclease free water was prepared *in house,* plastic wares such as 1.5 ml snap capped & screw capped Eppendorf tubes were purchased from Merck, screw capped polypropylene bottles, tips and Petri plates were purchased from Tarsons.

Preparation of Magnetizable Cellulose beads

*M*agnetizable Cellulose with specifications as follows: 75:25 % Ratio (Cellulose: Iron oxide), 20 mg/ml solid content in slurry in nuclease free water, < 2 µm average particle size, 10 µm cut off limit, > 40,000 cm^2/cm^3 specific surface area, Saturation magnetization (Ms): 21.014 emu/g, Coercivity (Hc): 12.715 G, Retentivity (Mr): 0.27415 emu/g], was prepared[4] and characterized at BRIT Vashi, Navi Mumbai and provided to us. The beads were washed thoroughly with acetone and nuclease free (NF) water and reconstituted in NF water or Elution Buffer.

Bacterial strain used for the study

Laboratory Escherichia coli strain – E. coli DH5α preserved *in house* was used in the study.

Genomic DNA purification by using spin-column based Genomic DNA extraction kit

In the spin column based genomic DNA extraction protocol 300 µl of overnight culture of *E.coli* cells (10^9 cells) was pelleted, resuspended in 200 µl PBS, incubated with 4 µl of Lysozyme (100 mg/ml) at 37^{0}C for 30 mins followed by 4 µl of Proteinase K (20 mg/ml) at 55^{0}C for 30 mins, 1-2 ml RNase A at 37^{0}C for 10 minutes and Lysis Buffer (20 mM Tris HCl pH 7.5, 5.5 M Guanidine Hydrochloride, 1% Triton X-100, 2mM EDTA) at 65^{0}C for 10 mins. After lysis, 200 µl of absolute alcohol was added to the reaction mixture, loaded onto the silica membrane of a spin column, and centrifuged at 7000 g for 1 min. The membrane was washed with Wash Buffers 1 and 2 (WB 1 – 10 mM Tris HCl pH 7.5, 4 M Guanidine Hydrochloride, 1% Triton X–100, 57% Ethanol; WB 2 – 2 mM Tris HCl pH 7.5 20 mM NaCl, 80% Ethanol) before elution. Pure genomic DNA was eluted in 200 µl Elution Buffer (10mM Tris-HCl (pH 8.5).

Genomic DNA extraction by MagCell beads

In the MagCell bead based genomic DNA extraction protocol 300 µl of overnight culture of E.coli cells (10^9 cells) was pelleted, resuspended in 200 µl PBS, incubated with 4 µl of Lysozyme (100 mg/ml) at 37^{0}C for 30 mins followed by 4 µl of Proteinase K (20 mg/ml) at 55^{0}C for 30 mins, 1-2 ml RNase A at 37^{0}C for 10 minutes and Lysis Buffer (20mM Tris HCl pH 7.5, 5.5 M Guanidine Hydrochloride, 1% Triton X-100, 2mM EDTA) at 65^{0}C for 10 mins. After lysis, 560 µl of Binding Buffer (10% PEG-8000, 1.25M NaCl) and 20 µl of well suspended MagCell beads were added to the suspension and incubated at RT with intermittent mixing. The tubes containing the lysed cell suspension were then placed in magnetic rack and incubated for 5 mins at RT or centrifuged at 8000 rpm for 8 min. The clarified supernatant was aspirated, and the tubes were removed from the magnetic rack and the beads washed in 1 ml Wash Buffer (10% PEG-8000, 2.5M NaCl) twice. Pure genomic DNA was eluted in 200 µl Elution Buffer (10mM Tris-HCl (pH 8.5) by incubating the magnetizable cellulose beads in the elution buffer for 10 mins at RT with intermittent mixing, placing the tube on

magnetic rack for 5 min or by centrifuging and aspirating the supernatant.

Assessment and comparison of yield and quality of isolated DNA

The quantity and quality of the eluted DNA was checked in a NanoDrop 2000 spectrophotometer (Thermo Scientific). 1.5 µl of each sample was pipetted onto the pedestal and concentration of DNA in ng/µl & purity of samples calculated by the software associated with the instrument. Purity of samples was assessed by determining the ratio of absorbance at 260 nm vs. absorbance at 280 nm. Generally, ratio between 1.7-1.9 is considered as purity criteria for DNA. The integrity of DNA samples was analyzed by agarose gel electrophoresis. 8 µl of each sample mixed with 6X loading buffer was loaded onto the wells of 1.0% w/v agarose gel containing ethidium bromide and ran for 30 min at 80 V. After separation, the resulting DNA bands were visualized under UV light.

PCR and qPCR

PCR and qPCR were used to detect target sequences in the purified DNA samples. Genomic DNA got extracted by the above method was used in PCR and qPCR using the primers specific to E. coli (Forward primer:5'-TGGTAATTACCGACGAAAACGGC-3', Reverseprimer:5'-ACGCGTGGTTACAGTCTTGCG-3') with the amplicon length 110 bp. A Standard curve was generated using SYBR green with the below PCR Protocol

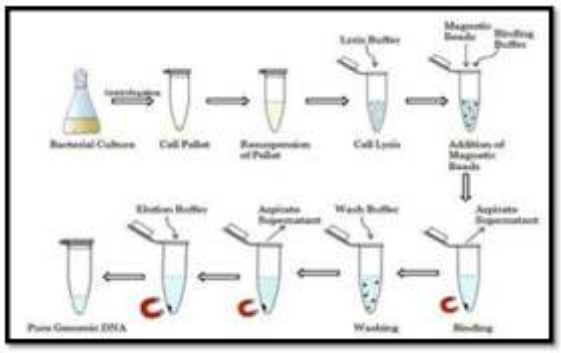
95°C-4 min (1 cycle)

95°C-25s, 52°C-40s, 72°C-30s (40 cycles)

Results and Discussion

Genomic DNA extraction from bacterial cells using magnetizable cellulose

The basic steps of DNA isolation are disruption of the cellular structure to create a lysate, separation of the soluble DNA from cell debris and other insoluble material and purification of the DNA of interest from soluble proteins and other nucleic acids. The principle is based on the reversible adsorption of nucleic acids to paramagnetic beads under appropriate buffer conditions. The composition of "Binding" and "Wash buffer" was adapted from US Patent No. 6855499 B1 2005.



Study of the effect of incubation time, number of washes

Effect of incubation time

As incubation time increases, Nucleic acid molecules get more time to bind on the surface of magnetic particles hence increasing the yield. Not much increase was seen as we increase the incubation time from 10 min to 30min. To keep the processing time less without compromising much on the yield, the incubation time was kept at 10 min.

Culture volume (µl)	Incubation time (min)	Yield (µg)	A 260/280
300	10	5.68	1.5-1.6
	15	6.4	1.5-1.6
	20	6.8	1.5-1.6
	30	7.28	1.5-1.6

Effect of number of washes

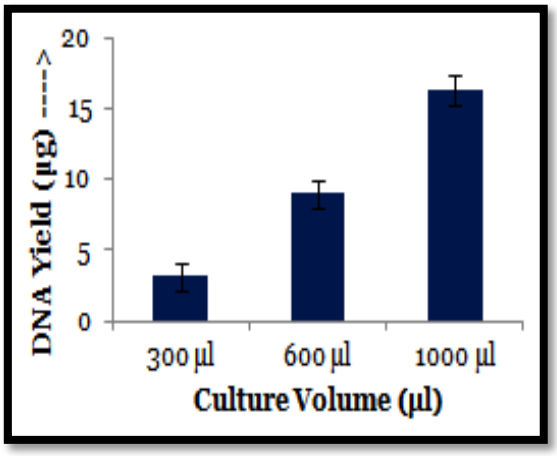
Washing of the nucleic acid bound magnetic particles removes the contaminants which may hinder the downstream applications.

Culture volume (µl)	No. of washes	Avg. Yield (µg)	A 260/280
300	1	5.4	1.5-1.6
	2	3.44	1.5-1.6
	3	3.16	1.5-1.6

Based on the above results, the number of washes was set at 2 to get the better A260/280 value. Increasing the washes beyond two washes is not increasing the purity.

Upscaling

Scaling studies were done with different culture volumes. As we increase the culture volumes the yield increases. Yield increased 5 times as we increase the culture volume from 300 µl to 1000 µl.



Culture Volume	Avg. Yield (µg)	A 260/280
300 µl	3.16	1.5-1.6
600 µl	9.0	1.5-1.6
1000 µl	16.36	1.5-1.6

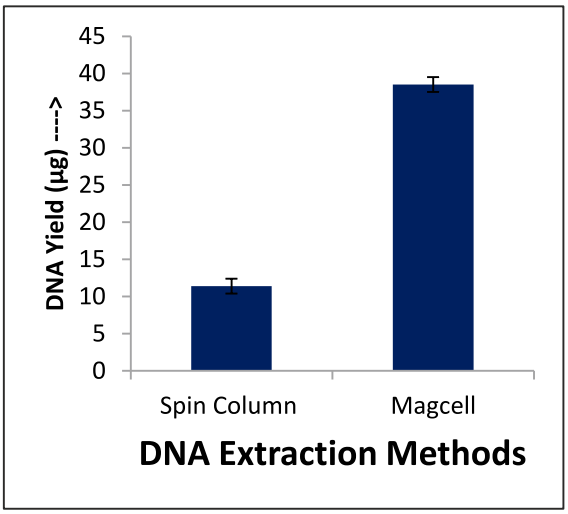
Effect of number of elutions

80% of the DNA is getting recovered in the first elution itself with 200 µl elution buffer. If one is particular with the yield, then only has to go for second elution.

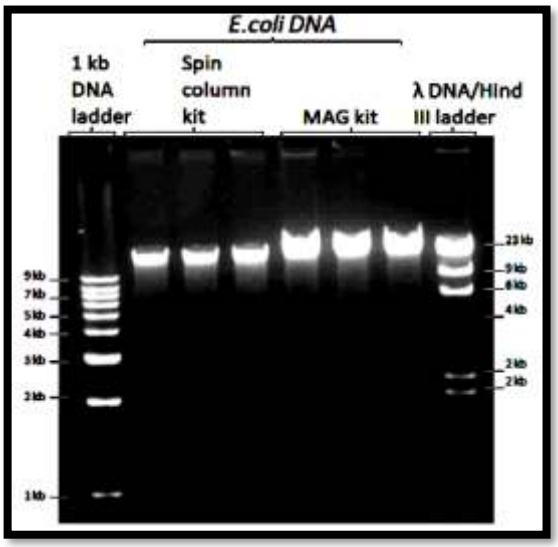
Culture Volume	1st elution (ng/µl)	2nd elution (ng/µl)	A 260/280
1000 µl	213.7	53.2	1.5-1.6
	237.0	43.8	1.5-1.6
	238.7	34.8	1.5-1.6

Comparison study of MagCell Vs Spin column

The effect of the parameters studied above taken into consideration and the protocol was optimised with incubation time 10 min and number of washes 2.With the optimized protocol, the performance of the kit was compared with the well studied in house commercial silica spin column kit. Silica matrices purification[5] is based on the high affinity of negatively charged DNA



Method	Culture Volume	Avg. Yield (µg)	A 260/280
Spin Column	1000 µl	11.38	1.9-2.0
Magcell beads	1000 µl	38.5	1.5-1.6



Extracted DNA size using mag kit-23 kb

Extracted DNA size using spin column kit ~10kb

backbone towards positively charged silica particles. Nanodrop readings and agarose gel images were given below.

qPCR Standard Curve

A standard curve was obtained using the extracted genomic DNA as template with different serial dilutions. Standard curve parameter values $R^2 = 0.995$ and efficiency 0.77. A good R^2 value signifies the good correlation. The low efficiency may be due to the use of desalted primers.

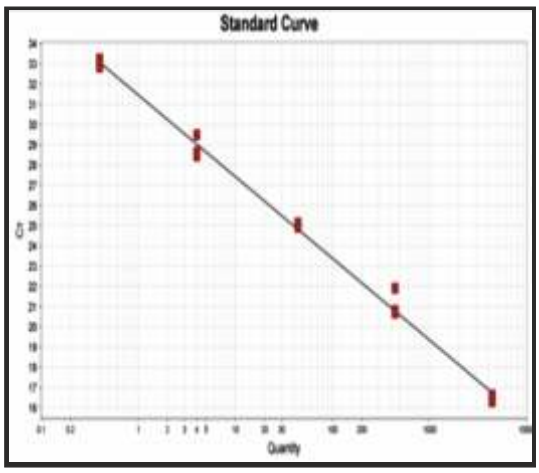


Fig: qPCR Standard curve-Mag particle kit-E. *coli* DNA

Stability studies of the kit

All the buffers were stored at room temperature and magnetic beads were stored at 4°C. The stability of the kit was checked by extracting genomic DNA from bacterial cells periodically. There was no change in the yield and purity throughout the study of one year. The kit was stable for one year.

Conclusion

A method was developed to extract genomic DNA from bacterial cells using magnetizable cellulose particles. The length of the extracted genomic DNA using magnetic particles is more compared to that of spin column method and can be used for all downstream applications like PCR, qPCR etc.

Acknowledgements

We want to acknowledge CE, BRIT for his kind support and guidance.

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An Overview of Computer Virtualization

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Introduction

Computer virtualization is a foundational technology in advance computing and networking which permits multiple Operating Systems (OS) and applications to run on a single physical machine. This is achieved by creating virtual forms of computer resources, *viz.*, hardware platforms, storage devices, and network resources[1-2].

Traditional Server Environment

Traditional server environment is a single-tenant server, it runs a single instance of OS, such as Linux, Windows, or any other operating systems. In this system an application is installed on a physical server. It consists of computer, motherboard, processor, hard drive, IO controllers, and memory etc. It is usually large and also referred as a bare-metal server.

Virtualized Environment

Virtualization is the process of simulating hardware and software in a virtual (software) environment. Virtualization uses a software (Hypervisor) to create an abstraction layer over the physical hardware and creates and manage Virtual Machines (VMs). Each VM runs its own OS and behaves as an independent computer, even though it uses a partial resource of the actual underlying computer hardware[3]. The structural graphical representation of traditional and virtualization systems is shown in Figure 1.

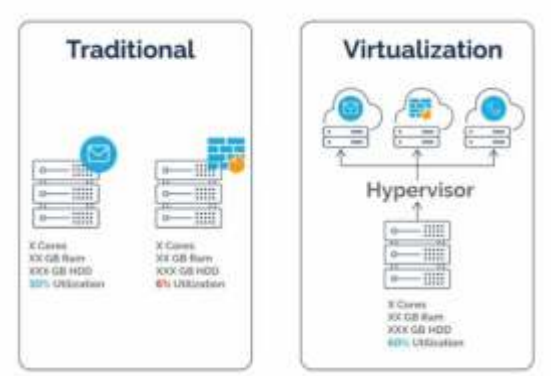

Fig. 1: Typical structural representation of the traditional and virtualization systems

Hypervisor

Hypervisor is a software abstraction layer that is used to create, run and manage multiple VMs on a single physical host machine. There are two types of Hypervisors, namely Type 1 Hypervisor and Type 2 Hypervisor. Type 1 hypervisor is installed directly on top of the physical server which is also known as Bare-metal Hypervisor. There are few widely used Type 1 Hypervisor are VMware ESXi, Hyper-V, Citrix XenServer, KVM, and Proxmox VE. Type 2 hypervisor is installed and runs on top of an existing OS installed on physical server and also known as Hosted Hypervisor. The few majorly used Type 2 Hypervisor are Virtual Box, VMware Fusion, and QEMU [4]. Figure 2 depicts the typical block diagram of the Type 1 and Type 2 Hypervisor.

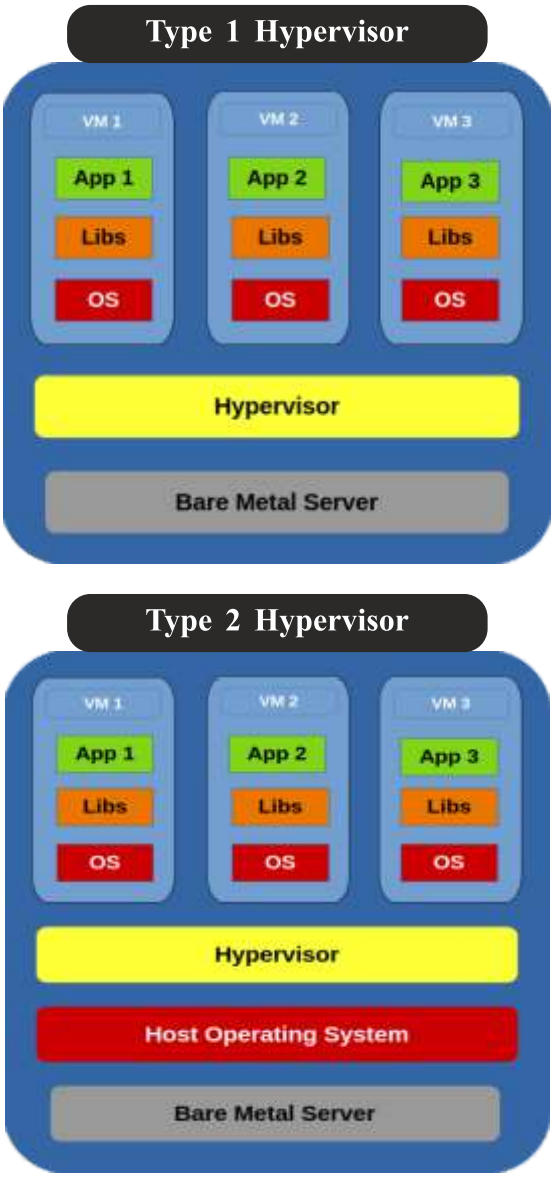

Fig. 2: Detailed block diagram of the Type 1 and Type 2 Hypervisor

System Virtualization

There are various systems which can be virtualized. Few important systems information is provided below and graphical representation is shown in Figure 3.

- **Desktop virtualization** allows creating and storing different users' desktop instances on a server, living in a data center or cloud.
- **Application virtualization** allows the user to use software that is not installed on their computer.
- **Server virtualization** is the process of running multiple virtual machines (VMs) on a single physical server.
- **Storage virtualization** enables multiple physical storage devices to be managed and accessed as a single logical device.
- **Network virtualization** is a technique that allows for the creation of multiple virtual networks that run on top of a physical network infrastructure.

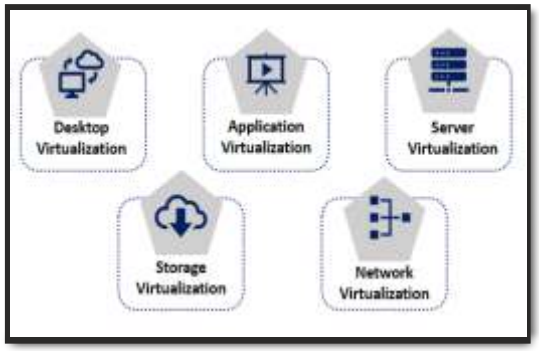

Fig. 3: Graphical representation of the various systems those can be virtualized

Advantages of Virtualization

1. Higher resource efficiency and reduces the information technology (IT) expenses

In a non-virtualized environment, a dedicated physical computer is required to each application. This results underuse of hardware resources, at a time computer is sitting idle and the resources cannot be used for other applications. While on the other hand in a virtualization a single physical server transforms into many virtual machines, these virtual machines can have different resources and OS that runs different applications while still all being hosted on the single physical hardware. The consolidation of the applications into virtualized environment is a more cost-effective approach because client be able to consume fewer physical computers, spend significantly less money on servers, server space, server cooling systems and lower energy footprint for the deployment.

2. Faster provisioning

Buying, installing and configuring of the hardware for each application is time-consuming. If the hardware is already in place, provisioning VMs to run the applications is significantly faster, user can create different templates, VM clones, VM snapshots, deploy easily and fast.

3. Minimal downtime and disaster recovery

When a disaster affects a physical server, recovery could take hours or even days while in the virtualized environment, it is easy to provision and deploy, allowing you to replicate or clone the virtual machine that is been affected. The recovery process usually take minutes or few hours only. As opposed to the hours, it would take to provision and set up a new physical server, significantly enhancing the resiliency of the environment and improving business continuity.

Conclusion

Computer virtualization is a transformative technology that has reformed the landscape of IT infrastructure. By facilitating more proficient use of resources, plummeting costs, and enhancing flexibility. Therefore, now a days, virtualization has become an indispensable tool in the field of modern computing and networking.

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Bone-seeking Radiopharmaceuticals: An Overview

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Background

Bone is one of the main constituents of the human body and accounts for ~14% of the total human body weight. Like other normal organs in the body, it is prone to attack by the cancer cells (primary and secondary) leading to abnormalities in the bony structure and elevation in bone pain. Primary bone cancer, also called bone sarcoma, is a rare cancer type and treatable to a large extent with a high 5-year survival rate close to ~70%. Secondary bone cancers are the more dreadful form where cancer originates primarily at breast, prostate or lung and then metastasizes to the bony tissue. In fact, bone is the third most common site for metastasis after lungs and liver[1]. Once cancer spreads to the bones it is very difficult to cure the disease, and the primary goal of the treatment remains to shrink, stop, or slow its growth to alleviate the pain (palliation) to help improve the quality of the patient's life.

Bone contains two main types of cells - the osteoblast which forms new bone, and the osteoclast which dissolves old bone. These two cells are always working in tandem which helps keep the bones strong. Cancer cells can either turn on the osteoclasts which lead to the bones being broken down at a faster rate without new bone being laid first or trigger the osteoblasts which lead to new bones being formed without old bones being broken down. In both these cases, bones become prone to damage in comparison to normal bones. Spreading of cancer to the bones of the spine can press on the spinal cord which can cause severe pain. Also, as cancer cells damage the bones, calcium from the bones is released into the blood which can lead to problems caused by high blood calcium levels (hypercalcemia).

Radiopharmaceuticals for diagnosis

Accurate diagnosis of skeletal metastasis is critical for initial staging, prognosis, treatment planning and therapy monitoring, which may lead to increased survival rate[2]. X-ray and CT scans are more useful for osteolytic lesions while nuclear medicine scans (SPECT and PET) are more beneficial for osteoblastic lesions. Nuclear medicine scans also provide the advantage of scanning the whole skeleton with high sensitivity and result in early diagnosis but have a low specificity for differentiating between benign (degenerative and/or arthritic bone disease) and malignant lesions. BRIT produces and supplies a number of diagnostic radiopharmaceuticals for bone scintigraphy for routine Nuclear Medicine applications.

[^{99m}Tc]Tc-MDP SPECT scan

In the mid-1960s and early '70s, based on the findings from several studies by *Subramanian et al.*, it was revealed that bone metastases could be detected much earlier with scintigraphic methods than with conventional radiological methods by using the ability of ^{99m}Tc-labeled inorganic polyphosphates to assess the osteoblastic activity through their preferential binding with hydroxyapatite present within the bone matrix[3,4]. With ^{99m}Tc being readily available from the ^{99}Mo-^{99m}Tc generator that was newly discovered at that time, bone scintigraphy quickly became one of the most commonly performed diagnostic imaging procedures and firmly cemented nuclear medicine as a powerful diagnostic tool.

However, it soon became apparent that pyrophosphate impurities or degradation products were responsible for most of the bone-imaging properties of ^{99m}Tc-labeled polyphosphates, and hence, ^{99m}Tc-

polyphosphates were abandoned in favor of ^{99m}Tc-pyrophosphate. However, skeletal imaging with ^{99m}Tc-pyrophosphate was also marred by its prolonged circulation time. During this period, ^{99m}Tc-labeled bisphosphonates, which demonstrated higher skeletal uptake, faster blood-pool clearance, and superior *in-vivo* stability, were introduced. With the advent of kit-based strategy for the preparation of ^{99m}Tc-radiopharmaceuticals and the increased availability of gamma cameras, ^{99m}Tc-methylene diphosphonate ([^{99m}Tc]Tc-MDP) became adopted as the standard agent for skeletal scintigraphy[5]. The radiotracer binds with the Ca^{2+} ions in the hydroxyapatite molecule through chemisorption and is generally very sensitive towards areas of significant osteoblast activity, often seen in cases of metastases arising from prostate, lung, and breast cancers. However, primarily osteolytic lesions such as myeloma, renal cell, and thyroid cancers generally exhibit poor uptake [6].

BRIT manufactures and supplies a lyophilized MDP kit (TCK 30) on a weekly basis. The kit produced by BRIT is used for formulating the finished radiopharmaceutical at the hospital end by eluting out fresh ^{99m}Tc activity from a ^{99}Mo-^{99m}Tc generator and labeling the kit on a day-to-day basis. This is currently the highest selling kit after the renal imaging kits, highlighting the significance of the nuclear bone scintigraphy.

[^{18}F]NaF PET scan

Although [^{18}F]NaF was introduced much earlier as a bone-seeking agent (first reported in 1962 by Blau et al.), it lost its popularity largely because of the easy availability and better physical characteristics of ^{99m}Tc viz. longer half-life and lower photon energy for imaging with gamma cameras. It, however, re-emerged in the 1990's with the introduction of commercial whole-body PET scanners[1,7].

The mechanism of uptake is the exchange of $^{18}F^-$ ions for an OH^- ion present on the surface of the hydroxyapatite matrix to form fluoroapatite. The best thing about this tracer is the minimal binding with serum proteins which permits whole-body imaging as early as 45-60 min after tracer injection whereas it is necessary to wait 3-4 h after the injection of [^{99m}Tc]Tc-MDP due to the comparatively slower clearance kinetics of the protein-bound fraction[7]. In addition, [^{18}F]NaF PET has higher spatial resolution, higher target-to-background ratio, and higher overall sensitivity in lesion detection which is especially helpful for detection of small metastases in the spine[1].

[^{18}F]NaF is produced in the Medical Cyclotron Facilities at Parel and Kolkata on a daily basis. Because of the short half-life of ^{18}F, the shipments are restricted to regions in and around cyclotron centres. Nevertheless, with the emergence of several medical cyclotrons in the country through active participation of the private sector, there has been resurgence in the use of this radiopharmaceutical at various PET-CT centres across the country.

Radiopharmaceuticals for targeted therapy

Although treatment with analgesics, hormones, chemotherapy with bisphosphonates and external beam radiation therapy have been found to be effective to a certain extent, they lack target specificity which in turn gives high exposure to non-target organs. On the other hand, radiopharmaceuticals intended for the treatment of bone metastases are incorporated into bone by one of two major mechanisms. Radionuclides residing in Group 2 of the periodic table carry the same divalent charge as elemental calcium and are incorporated into bone matrix directly whereas most other radionuclides are not efficiently targeted to bone naturally and instead are chelated to organic phosphonates, thereby facilitating a targeted therapeutic approach.

Radioisotopes emitting α or β^- particle or auger electrons are the preferred choice for the treatment of primary bone tumors such as osteosarcoma as well as for the palliation of painful skeletal metastases. Although, α- and auger electron emitters would be ideal for this purpose from the point of view of their high linear energy transfer (LET), which would lead to lesser myelotoxicity and would also be more effective for micro-metastatic lesions, paucity of such radioisotopes is a major issue. β^- particles, on the other hand, are emitted as a continuum of energies up to a maximum value and thereby in

addition to the specifically targeted cells, neighbouring cells that fall along the path of the radiation or in other words, are within the range of the radiation are also affected in a similar way (cross-fire effect). This also offers a distinct advantage of choosing the appropriate radioisotope depending on the size of the tumor[8]. The radiopharmaceutical of choice should also exhibit selective uptake and prolonged retention at the metastatic sites in contrast to normal bone i.e. high tumor-to-normal bone ratio, fast clearance from normal bone and soft tissues, high *in-vitro* and *in-vivo* stability, and favorable *in-vivo* pharmacokinetics to ensure therapeutic efficacy. BRIT produces and supplies a number of therapeutic radiopharmaceuticals based on various radioisotopes produced in the Dhruva reactor.

Common radiopharmaceuticals used for bone pain palliation

[^{32}P]Sodium phosphate

^{32}P ($t_{1/2}$ = 14.3 d, $E_{\beta(max)}$ = 1.71 MeV) in the form of Sodium phosphate was the first radiopharmaceutical used for the treatment of bone metastases based on the premise that phosphorus is one of the major components of bone and is taken up by the calcium hydroxyapatite structure. This was one of the initial products launched from BARC for therapeutic end use. The long half-life of ^{32}P and correspondingly its long shelf-life of 2 months for clinical end use allowed off-the-shelf availability of the radiopharmaceutical at the production end. However, ^{32}P is also strongly incorporated into critical intracellular constituents such as RNA and DNA. It also results in a great deal of unwanted radiation dose to the bone marrow due to its higher β^- energy (thus a greater range) leading to suppressed red cell production (Myelosuppression). This myelotoxicity has resulted in the discontinuation of this radiopharmaceutical in the clinical set up in favor of several other improved radiopharmaceuticals for similar application[9-11].

[^{89}Sr]$SrCl_2$

^{89}Sr ($t_{1/2}$ = 50 d, $E_{\beta(max)}$ = 1.46 MeV) is used in the form of [^{89}Sr]$SrCl_2$ since it behaves like calcium inside the body and is taken up in areas of osteoblastic bone metastases through ion exchange with the surface calcium ions of the hydroxyapatite crystals. Interestingly, this process is reversible and since Sr is slightly larger than Ca, a slightly distorted Sr-hydroxyapatite crystal structure results which makes the preference lie towards Ca and leads to a reabsorption of ^{89}Sr from normal bone into blood and other fluids. This mechanism is also responsible for the redistribution of ^{89}Sr from primary bone cancers and therefore this agent is not very useful for the treatment of cancers arising from osseous tissue and is primarily effective for metastatic lesions where there is preferential uptake and long-term retention[9-11]. For the latter case it is considered a 'gold standard' and sold under the trade name Metastron®. However, Sr-89 needs a high energy neutron flux for its routine production and hence the radioisotope is under development at Fast Breeder Test Reactor (FBTR), Kalpakkam. Efforts are underway to commercialize the product through BRIT for its clinical use which would work as a cost-effective import substitute.

[^{153}Sm]Sm-EDTMP

^{153}Sm is a medium energy β^- emitter [810 keV (20%), 710 keV (50%), and 640 keV (30%)] that decays with a physical half-life of 46.3 h. ^{153}Sm being a lanthanide is known to reside in bones with a biological half-life of ~10 years. To minimize the non-target uptake and increase the specificity towards cancerous tissue, it is chelated to ethylenediamine tetramethylene phosphonate (EDTMP), which targets the bone matrix with the chemisorption mechanism characteristic of phosphonates. The medium energy of the emitted β^- particles are advantageous in comparison to those of ^{32}P and ^{89}Sr in view of the suppression of bone marrow function, which limits the maximum dose that can be administered to patients. [^{153}Sm]Sm-EDTMP is rapidly taken up by the osteoblastic lesions in proportion to osteoblastic activity and is almost completely excreted within 6 h after administration. Additionally, using the 103-keV gamma-photon, the biodistribution of [^{153}Sm]Sm-EDTMP can be imaged with a gamma camera.

An important point to note for this radiopharmaceutical is that the [^{153}Sm]Sm-EDTMP complex is not kinetically inert and is prone to degradation inside the human body. To prevent such *in-vivo* complex degradation, a large excess of ligand is required (ligand-to-metal ratio approximately 120 to 250:1) in the clinical formulation to sequester any non-chelated ^{153}Sm which gets generated *in-vivo* which would otherwise be rapidly hydrolyzed to insoluble hydroxides, colloids, or other polymeric forms and end up in the liver[9-11]. BRIT produces this radiopharmaceutical on a monthly basis and is one of the most popular radiopharmaceuticals for bone pain palliation among the nuclear medicine fraternity.

[$^{186/188}$Re]Re-HEDP

There are two radionuclides of rhenium viz. ^{186}Re [$t_{1/2}$ = 3.7 d and $E_{\beta(max)}$ = 1.07 MeV, E_γ = 137 keV (9%)] and ^{188}Re [$t_{1/2}$ = 16 h and $E_{\beta(max)}$ = 2.1 MeV, E_γ = 155 keV (16%)] which are used to form stable bisphosphonate complexes with hydroxyethylidene diphosphonate (HEDP) for the purpose of palliative treatment. Both these radiotracers can be prepared using a lyophilized kit type approach using stannous ions in the presence of excess diphosphonate ligand for simultaneous reduction and complexation. Ascorbic acid is also used in the kit as an excipient to prevent re-oxidation of $^{186/188}$Re to perrhenate and to act as a free-radical scavenger to inhibit self-radiolysis. However, although the synthetic chemistry and chemical composition of [^{99m}Tc]Tc-MDP and [$^{186/188}$Re]Re-HEDP are similar, there is a striking difference in the biodistribution of these two agents, as exhibited by the faster wash-off rate of [$^{186/188}$Re]Re-HEDP from femurs in normal rats. This arises from the *in vivo* oxidation of the $^{186/188}$Re(IV) bridged by HEDP to soluble [^{188}Re]ReO_4^- which undergoes wash-off and is ultimately excreted primarily through the renal system [9-11]. ^{188}Re is available through ^{188}W-^{188}Re generators which favor the use of this radiopharmaceutical for palliative application. However, the production of parent ^{188}W radionuclide for generator application needs a high flux reactor with ~10^{15} neutrons/cm^2/s, which limits the availability of the generator and the products based on this radioisotope for nuclear medicine applications. There are a few nuclear medicine centres in the country which import this generator for clinical applications. BRIT has catalogued HEDP kit for [^{188}Re]Re-HEDP production, however its demand is limited due to very few users in the country because of the reasons cited above.

Recent advances in bone pain palliative radiopharmaceuticals

[^{177}Lu]Lu-EDTMP

^{177}Lu is an attractive radionuclide for developing bone pain palliative agents due to the emission of β^- particles of comparatively lower energy [$E_{(\beta max)}$ = 497 keV] which minimizes any possible damage to the bone marrow. The 6.7-day physical half-life of the radioisotope is also logistically favorable for supply of ^{177}Lu-radiopharmaceuticals to distant locations from BRIT, Vashi Complex.

The lower energy 113 keV (6.4%) and 208 keV (11%)] gamma photons also allow scintigraphic detection of the radiotracer *in-vivo*, thereby enabling dosimetry calculations. The high cross section of the ^{176}Lu(n,γ)^{177}Lu reaction [σ = 2100 barns] also allows large-scale production of relatively high specific activity ^{177}Lu even with medium flux research reactors, utilizing natural Lu target, thus ensuring the widespread availability of the radiopharmaceutical at economical costs [9].

[^{117m}Sn]Sn-DTPA

^{117m}Sn is produced from the inelastic neutron scattering of an enriched ^{117}Sn target. It differs from other radionuclides in terms of the mode of radioactive decay and bone deposition mechanism. ^{117m}Sn decays to ^{117}Sn by an internal conversion process that is accompanied by the ejection of Auger electrons having significantly lower energy than the other β^- emitting radionuclides discussed above, raising a lower risk of myelosuppression. When internalized, the energy of the emitted conversion and Auger electrons are deposited within the subcellular range to provide an optimal therapeutic outcome.

[^{117m}Sn]Sn-DTPA chelate does not have any affinity towards hydroxyapatite and DTPA only stabilizes the radiometal in its quadrivalent state (4+) in which Sn behaves as a natural bone-seeker. The mechanism for localization is thought to be the precipitation of stannous oxide on bone surfaces or by a hydrolysis reaction with hydroxyapatite. Unbound complex is rapidly cleared from the blood via the kidneys by virtue of its negative charge[9-11]. Similar to ^{89}Sr, ^{117m}Sn needs a fast neutron flux for its production. This radionuclide has been successfully produced in FBTR, Kalpakkam at laboratory level. However, because of availability of other therapeutic radiopharmaceuticals for similar application the radionuclide is not being explored for its translation to clinical use.

[^{223}Ra]RaCl$_2$

The α-emitting radionuclide ^{223}Ra is another example of a radiometal having natural affinity for metabolically active bone due its chemical similarity with calcium. Due to the high LET of alpha particles, use of [^{223}Ra]RaCl$_2$ as a palliative agent can cause a significant amount of irreparable double strand DNA damage rendering cellular repair mechanisms ineffective, with an additional advantage of minimal exposure to the nearby bone marrow [9-11]. This product got commercialized in the international market under the trade name Xofigo®. Currently, ^{227}Th-^{223}Ra generators are being developed worldwide with an aim to conveniently produce fairly large batches of ^{223}Ra. Radiochemistry Division (RCD), BARC has recently developed a generator system to ensure its availability in the Indian market on a regular basis and studies for its clinical deployment in Nuclear Medicine centres are underway.

Side Effects

Although bone marrow suppression is the primary side effect of palliative agents, onset of increased pain in the bone lesions within a few days after the administration of the drug is another side side effect that is observed with all the common radiopharmaceuticals. This is known as “flare response” which is usually short lived (3-7 days) and is thought to be caused by swelling of the tumor tissue from the initial radiation damage. This is mostly expected in the cases of ^{186}Re and ^{153}Sm because of their relatively short physical half-life, which would result in a larger radiation dose to be deposited much quicker than with either ^{89}Sr or ^{32}P. Radiation damage to any of the non-target organs is rare, except in the case of ^{32}P because of its high uptake in the spleen and liver, combined with slow excretion over several days.

Future Directions

The field of bone-seeking radiopharmaceuticals is rapidly evolving with ongoing research aimed at improving the efficacy and safety. In this regard, new radioisotopes like ^{170}Tm with favorable nuclear decay properties, ligands having improved targeting like DOTMP, hydroxyapatite (HA) and BPAMD, novel approaches like “radioisotope cocktails” of ^{153}Sm or ^{177}Lu with ^{170}Tm to provide both early and sustained long term pain relief to patients in early stage of disease and combination therapies to enhance therapeutic index are being explored. The future lies in the development of personalized medicine approaches through the understanding of the genetic and molecular profile of patients which will allow for the customization of radiopharmaceutical therapies, optimizing treatment efficacy and minimizing side effects. Additionally, advances in imaging technology and artificial intelligence are expected to enhance diagnostic accuracy and treatment planning.

Conclusion

Bone-seeking radiopharmaceuticals have transformed the landscape of nuclear medicine, providing powerful tools for the diagnosis and treatment of bone-related diseases. DAE has played an important role in the country for facilitating the availability of useful radioisotopes/ radiopharmaceuticals for bone cancer management. India is among the few countries in the world to have its own indigenous mechanism for facilitating the newer radioisotopes for Nuclear medicine

applications. Although designing effective radiopharmaceuticals with an aim to maximize the radiation dose to the cancer cells in bone and minimize radiation-induced bone marrow suppression is indeed a great challenge, with ongoing research and technological advancements even greater precision and efficacy in the future could be expected, ultimately improving patient outcomes in skeletal health.

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Review Article

Role of Scientific Communications for Development of Society – A Guide to Publish a Research Work Effectively

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Abstract

Science is an influential tool for understanding the world around us, but it can be difficult for common man to understand the multifaceted scientific concepts. Science communication is a growing area of practice and research. Over the years, developments in science and technology have resulted in reflective increases in the quality of life and health of people, throughout the world, and all indicators propose that they will continue to do so long into the future. Past four decades, has shown a steady increase in number of activities, courses, and practitioners trying to propagate science to common man. But what actually is science communication? How is it different to spreading public awareness of science or public understanding of science, or, even scientific culture, and scientific literacy? The author reviews the literature to draw together a comprehensive set of definitions for these related terms. An amalgamating structure is presented and a current definition of science communication is positioned within this context.

The research scientists and engineers make their research accessible to the scientific community by publishing them in scientific journals, in various formats. If the findings or research that is carried out aren't communicated, the hard work put in to execute that science goes wasted. In scientific and technical papers, the scientists explain the research that they are building on, their research methods, share the data and data analysis techniques, along with the interpretations of their statistical information.

Comprehending the ways to read and write the scientific papers is a crucial skill for scientists, engineers, budding science students, research scholars etc. In this article, the author attempts to highlight the role of scientific communications for understanding scientific and technical articles and the process of publication in journals, in the constantly fluctuating modern society.

Science & Scientific Communications

How can one define the term 'science'? The word "science originated from the Latin word, "Scientia", meaning "knowledge"[1], and thus, in its broad usage, the word 'science' often meant 'knowledge', and the word 'Scientific' means "pertaining to science" (i.e. demonstrable knowledge). The Panel on Public Affairs of the American Physical Society, for example, proposed a definition that some describe as pure science: "Science is the systematic enterprise of gathering knowledge about the world (any subject) and organizing and condensing that knowledge into testable laws and theories"[2]. They went on to explain that ". . . the success and credibility of science is anchored in the willingness of scientists to expose their ideas and results to independent testing and replication by other scientists (and) abandon or modify accepted conclusions, when confronted with more complete or reliable experimental evidence"[3]. Many dictionaries (e.g., New Shorter Oxford English Dictionary, 1993) amplify this definition by highlighting the use of the scientific method as the way of identifying any activity as part of science. The report "Science for all Americans" identifies the fact that science is carried out in, and consequently influenced by, its social context[4]. Science is a human activity, and scientific contributions have come from people from a wide range of different backgrounds and cultures. Historians of science increasingly see their field as part of a global history of exchange, conflict and collaborations[5,6].

Many branches are grouped together under the banner of 'Science'. For e.g., 'Mathematics' may also be viewed as the dialect of science, in fact, Mathematics is considered as the 'mother of all sciences' because it is a tool which solves problems of every other science and Carl Friedrich Gauss, the famous mathematician, after which one of the prizes is named, is said to have stated that mathematics is 'the queen of sciences'. Whereas 'Technology' and 'Medicine' are frequently considered as applications of pure science, 'Engineering' is often regarded as the link between 'Pure Science and Technology'[5]. In recognition of this problem, abbreviations such as S&T (Science and Technology), SME (Science, Mathematics & Engineering), S&E (Science & Engineering), and SET (Science, Engineering & Technology) are often used to define more precisely, or to group together science-related endeavours[2]. In the modern time, the amalgamation of all of these terms in the focussed research, together, brings out wonderful outcomes.

There is a considerable commonality between the terms, 'public awareness of science', 'public understanding of science', 'scientific literacy', and 'scientific culture', but these should not be used interchangeably. The intention of the term "Public awareness of science" is to stimulate awareness of, and positive attitudes (or opinions) towards science, while the term, "Public understanding of science (PUS)", focusses on understanding science: its content, processes, and social factors. "Scientific literacy" means the ideal situation where people are aware of, interested and involved in, form their opinions about, and seek to understand science, whereas, "Scientific culture" may be used where a society-wide environment exists that appreciates and supports science and scientific literacy. It has important social and aesthetic (affective) aspects[2].

Science communication (Sci-comm) involves simplifying technically complex scientific topics and crafting them into accessible, informative, and compelling content for specific audiences. This audience could be scientific peers, the media, potential investors, government or other leadership decision-makers, or the general public. It is the practice of informing, educating, and raising awareness of science-related topics. **This may refer to communicating to non-specialists, as well as, to expert-to-expert communication, associated with scientific publishing.** Sci-Comm is defined as the use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses to science (the **AEIOU vowel analogy**): Awareness (including familiarity with new aspects of science), **E**njoyment (or other affective responses, e.g., appreciating science as entertainment or art), **I**nterest (as evidenced by voluntary involvement with science or its communication), **O**pinion-forming (conforming of science-related attitudes), and **U**nderstanding (of science, its content, processes, and social factors). The definition provides an outcomes-type view of science communication, and provides the foundations for further research and evaluation. Science communication may involve science practitioners, mediators, and other members of general public, either peer-to-peer or between groups[2].

What are the different forms of science communication? Scientific communication methods include publishing their work in scientific journals as articles, or, speaking about their work in conferences and seminars, formal public talks or lectures, through digital media, such as, emails and social networks, and one-on-one dialogues, or, group discussions. The common examples of informal science communications include Science center's and Museums; Media programs or coverage on film, T.V., radio, or in print; Community or internet forums on scientific topics; Science groups, clubs, associations, or societies; Science shows and theatres; Scientific exhibitions; Scientific competitions and/or events, etc. However, it is the researchers who are most benefitted by good science communications between the Scientific community.

The communiqué between scientists and the public is constantly changing. Major reasons for these changes may be attributed to the rapid progress of the Internet, now in its web 2.0 version, with an abundance of video-sharing websites, blogging platforms and social networks; the ubiquity of mobile devices; and the merging of

individual and public communication. The new infrastructures allow nearly instantaneous access to information and make it much easier for communicators—both professionals and lay persons or general public, at large—to directly address a broad audience. Web-based services have broken down technical and economic barriers that, in the traditional communication system, have separated professional communicators from the largely passive audience of traditional print and broadcast media. This interactivity among the participants of online communication potentially transcends the traditional model of mass communication—by which the information is transmitted from a sender, that is, the scientists, via journalists to the audience[7].

The impact of these developments for public science communication cannot yet be fully anticipated. Most obvious are the changes in communication strategies, that is, the use of communication channels and corresponding "formats" by which the scientists and scientific organizations addresses the public. Many audiences relevant to science are now online, and communicators have to meet them there. Science blogs, Twitter, Facebook, Google+ and YouTube now play a significant role—often providing original content, but also directing attention to projects, findings, events, scientific publications, reports or political decisions that are relevant to science. The new digital media, by offering new communication channels and formats, may, in the long run, fundamentally transform the interface between science and society [8,9].

The Need for Good Science Communication

Why is science communication so important amongst the scientific community? Research and innovation systems have the crucial role of generating new knowledge or findings, and can transform fundamental scientific knowledge into concrete applications. Societal challenges, such as pandemics, artificial intelligence, big data, food security, many facets of medicine, or energy and climate threats highlight the importance of investment in research and of research-informed evidence. However, great science does not speak for itself: it is critical that scientific evidence is readily available and easy to understand.

The role of researchers and research institutions is changing and also their engagement in science communication, which now often includes stakeholder involvement and public engagement. The context in which (science) communication takes place is more and more polarized, varied, and volatile. Proper science communication is the key to research-informed policy making, and societal debates. Communication and interaction with various audiences, including other researchers and citizens, should take place at all stages of the research process so as to contribute to excellent science.

Scientists recognize that making research understandable, engaging, relatable and impactful – especially to non-scientific audiences – is one of the most important tasks they need to carry out, otherwise no one will see or understand the impact of their work. In fact, 90% of researchers and 86% of research managers, who participated in a Nature Masterclasses survey, believe that communication is a key skill for a successful research career.

It is not only the researchers themselves who stand to benefit from good science communication. Science will always finds its way into popular culture and – if done well – can engage and educate the public, and motivate and inspire budding researchers of the future. Yet, despite recognizing the need to communicate about their work, 81% of researchers surveyed by Nature Masterclasses told that conveying complex science to non-science audiences is an area they struggle with. In many ways responsible research and innovation (RRI) can be viewed as the latest iteration of Science and Technology Studies (STS)-inspired policy developments which seek to enable a more robust relationship between science and society, and which have influenced research and practice in public science communication [9,10].

Researchers in the hard-core sciences still tend to regard public communication of science as different from internal scientific communication, notably, scientific publications, conferences and workshops [11]. As a scientist, it is so important to communicate the results of research in an

appropriate manner. The scientific research that is carried out may have profound impacts on the respective fields of science, and ultimately, on society, and yet if we do not share our results, how will anyone ever be able to benefit from the results of that hard work? Moreover, by communicating research results with colleagues in the scientific community, we allow ourselves to receive credit for doing the work, connect with others doing similar work, thereby, leading to new collaborations, and establish our results within the scientific knowledge base that future research will be built upon.

What are the common modes of scientific communication amongst the researchers? Various modes of scientific communication are: (a) Making a scientific or technical presentation (or poster), (b) Writing technical reports, (c) Writing scientific papers, (d) Writing research or project proposals, and (d) Data analysis and information from the Web (The Web offers virtually unlimited resources, information and examples for scientific communication). These diverse communication activities require skills, such as, (a) Computer and technical proficiency, (b) Organized thinking and ability to abstract ideas, (c) Good mastery of language, (in the global context, often in English), and (d) Differentiating and understanding the objectives of each communication mode (audience, clients, goals etc.).

(a) **Elements of effective scientific presentation:** 1) One should have a knack of explaining your research, may be as an interesting story and has a good flow, as per the specific audience, 2) The work should be defined as: Outline, coherence, clear message and continuity, 3) Creating slides – simple and clear content, 4) Delivering – practice, take control, show enthusiasm, look at the audience, even when nervous and lack of confidence, 5) A presentation is very different as compared to writing a paper or a report

(b) Scientific/technical proposal: Title (orient the audience); Introduction; Problem statement; Assertions set up proposed solution; Assertions are supported; Proposed solution is pitched (does solution make sense from technical point of view? Does it make sense from management point of view? Can the proposal writers do it?); Objectives are concise, clear and logical Plan of work – in connection with objectives (how solution is developed); Management plan – timeline, budget, Q-A, collaboration; References; Appendices - facilities, qualifications (CV).

©) Scientific Journal Publications: The structure of a scientific paper includes: Title (orient the audience); Authors and affiliations; Abstract (What was done in a nutshell?); Introduction (What is the problem addressed?); Theory/Methods (How did we solve the problem?); Results (What did we find?); Discussion (What does it mean?); Conclusions [What have we learnt (in short)]?; Acknowledgements (Who helped us?); and References (Whose previous work did we rely on?); Appendices (Additional information) (If any). This part would be dealt in the paper, in detail.

The History of Scientific Journal Publications

The word "journal" comes from the French word, "jour", meaning "day"[12]. Early English usage of the word "journal" goes back to the 14th century (1355-56) and means "book of church services" in which passages for use on a specific day of the year were included[13,14]. In 1540, the meaning shifted to the daily record of commercial transactions and in 1552, it became associated with "the journey", a book containing notices concerning the daily stages of routes and other information for travelers[14]. In 1565, it meant a record of public events that occurred day by day or on successive dates[13,14]. In 1610, it meant a record of events of public events of personal interest for their own use[13,14], and in 1728 "Journal" became synonymous with "newspaper" and extended to any periodical publication. Nowadays, "Journal" refers to a periodical issue on time-frame basis, such as, daily, fortnightly, monthly, or yearly[15]. A "Scientific Journal" is a periodical publication aiming to provide a channel for scientific communication[16], and an "article" is considered as a basic unit of research communication[17].

The history of scientific journal publications can be traced back to the 17th century, when scientists began to share their ideas with other fellow scientists through “letters” and “meetings”. The first scientific journals were published in the Year1665. During January 5, 1665, the French '*Le Journal des Sçavans*' (Journal of the experts) was published in France, and, on March 6, 1665, Henry Oldenburg published the first printed version of the papers presented in the meetings and a monthly periodical, *Philosophical Transactions of the Royal Society*, was born[18].

The Philosophical Transactions pioneered the concepts of scientific priority and peer review, which are still used today. The term "philosophy" in the journal's name refers to "natural philosophy", which was the common term for science at the time. In the 18th century, over a thousand scientific journals were founded, but most were short-lived. In 1970s, peer review began, allowing lesser-known researchers to publish their work in more prestigious journals.

Articles in scientific journals can be used in research and higher education. Some classes are partially devoted to the explication of classic articles, and seminar classes can consist of the presentation by each student of a classic or current paper. In a scientific research group or academic department, it is usual for the content of current scientific journals to be discussed in journal clubs. The standards that a journal uses to determine publication can vary widely. Articles tend to be highly technical, representing the latest theoretical research and experimental results in the field of science covered by the journal. They are often incomprehensive to anyone except researchers in the field and advanced students. In some subjects this is inevitable, given the nature of the content. Usually, rigorous rules of scientific writing are enforced by the editors; however, these rules may vary from journal to journal, especially, between journals from different publishers[19].

Scientific Journals, the history behind scientific journals, the types of journal articles, the format of these articles and the formal structure and guide to publish a research paper, would be addressed in a little more detailed manner in the present article.

Scientific Journals

A scientific journal is a periodical publication intended to further the progress of science usually by reporting new research. There are plethora of scientific and technical journals and most of these journals are highly specialized. Scientific journals contain articles and scientific papers across a wide range of scientific fields and these articles are peer reviewed, in an attempt to ensure that articles meet the journal's standards of quality, and scientific validity.

Most researchers know that communication is a key part of any research career. But very few feel confident in communicating their research to different audiences[19,20]. As a result, they could be missing out on opportunities to disseminate their research findings and raise their profile within and beyond their field. In this article, we delve into why it's crucial to communicate science effectively and how to assist researchers in sharing engaging stories about their work.

Types of Journal Articles

Different types of articles are published in varied scientific journals, that includes original research papers, technical brief, tutorial, expert view, case reports, technical notes, review articles, letters, editorial, guest editorials and commentaries. The most common types of journal articles vary by field and specific journal, but in general, the various types of Scientific journal articles include the following:

- **Letters (also called Communications/Brief Communications)/Research/Technical Note/Technical Brief:** This should not be confused with '*Letters to the Editor*'. This includes a very short description of important current research findings (in the form of full research paper but pointing to a specific finding) that are usually fast-tracked for immediate publication, because they are considered urgent. These are short preliminary report of current research findings that are not fully developed or interpreted, but maybe of potential interest to readers. Technical briefs/notes undergo full

peer review. The recommended length of a technical brief may be ~ 2500 words.

- **Research Articles:** These are usually between five to twenty pages and are complete descriptions of current original research findings, supported by graphs, flow charts, relevant Tables, and other statistical data.
- **Review articles:** These do not cover original research, but rather accumulate the results of many different articles on a particular topic into a coherent narrative about the state-of-the-art in that field. Review articles provide information about the topic and also provide journal references to the original research. Reviews may be entirely narrative, or may provide quantitative summary estimates resulting from the application of meta-analytical methods.

The essence of your work may be diagnosed by analyzing the following points: (1) Significance: Why was the said work done? Or the Scope and aim of your work. Did you solve some important problem of current interest or is it an obscure or obsolete problem? (2) Originality / Novelty: Is your approach novel or is it tried, tested & true? Did you need to develop new tools/procedures /methods, that were either analytical or physical? (3) Completeness: Have you tested a wide range of scenarios, or is your work simple proof-of-existing concept? (4) Correctness/Validation: Is the solution to the aim of your work technically sound or are their errors? If so, try to improvise the same.

Only after careful analysis in identifying the relevant answers to the above questions, one may proceed to start compiling and documenting your research work.

The Format of Journal Articles

Scientific journals have a specific formal structure that has to be understood by all those who read it (authors who wish to submit their research findings, readers as well as editors). The anatomy or the classical format for a research article may be explained by **SIMRAD**, i.e., **S**ummary (for Abstract), **I**ntroduction, **M**aterials & **M**ethods, **R**esults **a**nd **D**iscussion, followed by relevant **A**cknowledgements (if any) and **R**eferences.

(S) Summary (or Abstract) appear in the beginning of any article. In this part, the authors briefly describe the research question, the general methods, and the major findings and implications of the work undertaken. Providing a relevant summary helps the readers to decide whether the article in question discusses research that interests them and it is entered into literature databases as a means of providing more information to people doing scientific literature surveys. For both of these purposes. It is important to have a rather short version of the full story.

(I) Introduction: The central research question and important background information to the study is described in this section. Because science is a process that builds on previous findings, relevant and established scientific knowledge is cited here, and then, correspondingly these are listed in the Reference Section at the end of the article. Ideally, the Introduction ends with a clear statement about the authors' hypothesis to be tested and mentioned about in the research paper. It also provides an opportunity for the authors to show that they are aware of the work that scientists have done (on the relevant topic) before them and how their results may fit in, explicitly building on existing knowledge.

(M) Materials & Methods: In this section, the authors describe the research methods they used. All of the procedures, equipment, measurement parameters, etc. are described in detail, sufficient enough for another researcher to evaluate and/or replicate or reproduce the research. In addition, authors explain the sources of error and procedures employed to reduce and measure the uncertainty in their data. Here, the perspective of each of the journal may vary or differ. For example, a biochemical journal will be explicit about the analytical quality and source of the chemical reagents used for obtaining the data. Other journals, especially in clinical medicine, the data in the methods section will demand lot more information about the patient's data. In general, the detail provided in this section allows other scientists to evaluate the quality of

the data collected.

(R) Results: The data collected during the research are presented in this section, both, in written form as well as using various illustrations, such as, tables, graphs and figures. In addition, all statistical and data analysis techniques used are presented. More importantly, the data should be presented separately from any interpretation by the author(s). The big problem for the writer, editor and reader is how much of the data should be included in this section. The authors should be judicious to summarize the tables or other illustrations, so that the text and the hard data meet the findings to match with the interpretation of the data, so as to highlight the quality of data evaluation.

(D) Discussion and Conclusions: In this section, authors get the opportunity to present their interpretation of the data/findings, often including a model or idea they feel best explains their results. They also present the strengths and significance of their research work. Naturally, this is the most subjective section of the scientific research article, as it presents interpretation strictly on the basis of the methods and data obtained as opposed to mere speculations by the authors. Instead, this is where the authors combine their experience, background knowledge, and creativity to explain the data and use it as evidence in their interpretation. A final component of the conclusions involves placing the current work back into a larger context by discussing the implications of the work undertaken.

References: Scientific progress requires building on existing knowledge, and previous findings are recognized by directly citing them in any new work. The citations are collected in one list, commonly called, 'References', although the precise format for each of the journal varies considerably. The reference list may seem like something you don't actually read, but in fact, it provides a wealth of information about whether the authors are citing the most recent work, in their field, or whether they are biased in their citations towards certain authors.

Various Publishers and Journal-level-data: Publisher Selection

Elsevier, Wiley-Blackwell (Wiley), Springer, Nature and Taylor & Francis, are among the largest long-established academic publishers, which uses a mixture of subscription and for-profit gold open access licences. Multidisciplinary Publishing Institute (MDPI), Frontiers Media (Frontiers) and Hindawi are for-profit gold open access publishers who are well known for their business model that publishes many articles through 'special issues'. Bio-Medical Central (BMC) publishing is a part of Springer Nature, and has the best for-profit open access journals (but does not have 'special issues') covering over 250 titles and are always striving to drive progress in biology, health sciences and medicine. Lastly, PLOS is a **non-profit, Open Access publisher** empowering researchers to accelerate progress in science and medicine by leading a transformation in research communication. This publisher is among the largest publishers in terms of articles per journal per year.

Steps to Publish a Research Paper

The process of publishing a research paper can be intimidating and confusing, especially for first-time authors. This article provides a simple step-by-step guide with tips for each stage of publication, starting when the author has completed a first draft of the paper [21].

Step 1: Find a Journal

The first step in getting any paper published is to find an appropriate journal. The ideal journal for a paper will help deliver a paper into the hands of the target audience. The target audience may include other scholars who are researching the same topic, those in an adjacent field, or the general public. It is important to consider both *who* and *how many people* read a journal. A journal may target exactly the right audience, but if the audience consists of five people, it still may be a less effective choice than a journal that has a slightly less relevant audience of thousands of people.

Questions to ask to find the right journal:

- Who is the target audience?
- Which journals fit the scope of the manuscript?
- Does the manuscript match those typically published by the journal?
- What are high-impact journals that are relevant to the manuscript?
- How much of the manuscript must be changed to fit the journal?
- Which journals are open-access and which follow the traditional subscription-based model?

One way to identify journals with the right scope is to begin by looking at the reference section of your manuscript. Journals are likely to publish manuscripts on topics they have already published papers about. The format and style of your paper is also likely to match those of your reference section. In addition, authors of cited papers are a key part of the target audience, and they are likely to read journals they have published in.

Another way to identify journals with the right scope is to use a journal finder. This type of journal finder can not only help with identifying the scope of journals, but also the journal rankings and impact factors. Additionally, journals will put out special issues which target specific topics. Because journal editors need to fill a certain number of slots with relevant papers, special issues can provide an opportunity for newer authors to get published in journals with high impact factors. Overall, editors accept or reject papers based on how many papers they get and how much space they have for a certain issue. It is also important to make sure that your paper has a similar format to those published by the journal. Some journals publish short single studies, others publish multi-study experiments. Some journals publish theoretical results while others focus on more practical applications.

Because a research paper can be actively under review at only one journal at a time, it is important to prioritize which journals to apply to first. One strategy is to first identify journals with the right *scope* (i.e., focused on the right topic) and then rank them based on their *impact factor* (i.e., how many people the journal typically reaches with its articles). The manuscript can be sent first to journals with the highest impact factors, which are typically more prestigious and selective. If the paper is rejected, authors can seek the next highest journal on the list, repeating until the paper is accepted. Although this method is likely to include many rejections, it increases the chance that the paper is published in the best journal possible within the paper's scope, thereby reaching the most members of the target audience.

Another factor to consider is the business model of the journal. Broadly, there are two types of models: subscription and open access. In the traditional subscription model, publishers monetize their articles behind paywalls. One can usually only see the abstract of the article and must pay a fee in order to access the full article. Universities typically pay these publishers a large fee so that their faculty and students can access their articles at any time. For most subscription publishers, you must sign over the copyright of the final article to the publisher. This means that the publisher has the exclusive legal right to the final article and you are not allowed to share or distribute the article.

Open access journals allow authors to retain the copyright of their final article. These journals will get the right to host your final article, but it can be shared, reused, or adapted by anyone as long as they give credit to the original authors. As these journals do not make money via subscriptions, they typically charge a publication fee, or they may be funded and subsidized by a larger organization. Meanwhile, many subscription publishers will also allow you to pay an exorbitant fee, usually in the thousands of dollars, to make your article open access.

Other factors to consider are how long it typically takes for an article to be published, whether there are fees for publishing papers, and whether a journal is trustworthy. Certain high-quality journals (e.g., American Economic Review, Journal of Political Economy) charge a fee to deter low-quality submissions. Some outlets publish almost every manuscript without a peer-review. Some of them are free like SSRN, and some of them charge a fee. However, they do not evaluate the manuscript rigorously or do any serious review on it. Such outlets publish many low-quality papers, and it can be hard to distinguish between good and bad papers in those outlets.

"Predatory publishing" refers to the exploitative business model in which journals charge a fee for publication but do not rigorously evaluate or peer-review manuscripts. These journals have become more common in the era of open access publication. There are many helpful resources so you can be sure you are publishing your article in a reputable journal.

Step 2: Prepare and Submit the Article

Once a journal has been selected, the next step is to prepare the article for submission. Each journal has specific formatting requirements, which may vary based on what kind of manuscript is being submitted (e.g., review, commentary, report, peer-reviewed research manuscript). It is important to note that journals have different expectations for how tables, figures, and supplementary materials should be submitted. This information is typically available on the journal website, often with templates available for Word or LaTeX.

In order to submit a manuscript, most journals require authors to register for a portal on their website and designate a corresponding author for each submission. Once a manuscript has been submitted, the journal may respond and request some fixes for formatting errors or page limits. Once the manuscript has been submitted in an acceptable format, the next step is to await the editor's decision.

Step 3: Wait to Hear Back

When an article is submitted to a journal, the editor will decide whether or not they want to send the paper to reviewers. A *desk rejection* occurs if the editor rejects your paper before sending it out to the reviewers. If your paper is sent out to reviewers, there are a few possible outcomes you may receive: rejection, revision and resubmit (major revision), conditional acceptance (minor revision), or acceptance.

There is no set time when you can expect to hear back from the journal. Different journals go through the review process at different rates. It is not uncommon to have to wait more than six months for a response.

(a) Desk Rejection

A desk rejection happens when a paper is rejected before it has left the editor's desk, i.e., without being sent out to external reviewers. Often this is due to a lack of fit to the journal's scope, an insufficient contribution, or some major flaw in the manuscript. A desk rejection is typically the fastest kind of response and may happen after a couple of weeks. If you receive a desk rejection, the next steps are to address the criticism, improve your manuscript, and submit your manuscript to another journal.

You usually will not be informed if your manuscript is sent out to reviewers. Thus, if you do not hear back from the editor within a few months, it usually means that the manuscript has been sent out to reviewers. Because reviewers usually do not receive any credit or recognition for their work, they do not have much incentive to work or respond quickly. Thus, if the manuscript is sent to reviewers, it may take several months to get a response.

Once all of the reviewers have responded, the editor will consider all of their feedback and make a final decision. Ultimately, the editor has total control, and the reviewer comments are treated as suggestions. Editors may override the reviewers, and reject manuscripts even if the reviewers want the manuscript published. They may also decide to exclude some reviewers or their comments.

(a) Rejection

A rejection means that, after looking at reviewer feedback, the editor has decided not to accept the manuscript. This is a final decision and indicates that the editor feels that this specific paper is not a good fit for the journal.

After receiving a rejection, the next step is to seek another journal to publish the paper.

(b) Revise & Resubmit (Major Revision)

Papers are only rarely accepted without revisions. Instead, many manuscript authors receive a "Revise and Resubmit", also known as a major revision, which is somewhere between an acceptance and a rejection. The editor has identified significant issues with the manuscript but there is still hope for publication. In this case, the author should take the opportunity to improve the manuscript. Often revisions are significant; in some cases, they require re-analysis of data or even collection of new data.

Journals will frequently give you a list of documents that need to be submitted with the revision. Usually, you will need to include a respectful letter to the editor thanking them and the journal for their work. You will also need to submit a document with all the reviewer's comments and how you addressed their concerns in your paper. Sometimes you will need to submit two copies of your manuscript, one before the changes were made and one with all the changes highlighted.

(c) Conditional Acceptance (Minor Revision)

After you have properly addressed all the major revisions you may receive a "Conditional Acceptance", meaning that there are minor issues that need to be addressed before your manuscript can be published. The changes you need to do on your manuscript are usually smaller in scope here: grammatical and formatting changes, rewriting confusing paragraphs and adding more references where needed.

Your manuscript may go through multiple rounds of conditional acceptance, as reviewers may find more minor issues that need to be addressed. Also, you may have different reviewers after each revision, as reviewers can opt out even after previously reviewing your paper.

Step 4: Acceptance

Once all the reviewers and the editor are satisfied with your manuscript, you will receive an acceptance letter. Typically, you will have to prepare additional files and your final draft in a specific format for publication, and this can be different from what you did during the review process. If you are applying to a subscription-based journal you will also need to sign over the copyright for the final, published paper to the journal.

The time between when your paper is accepted and when your paper is actually published is variable, as editors need to fill space for each issue. It is not uncommon for your paper to be published over a year after the final acceptance.

Conclusion

The first science journals appeared in Europe towards the end of 17th Century, but the big expansion has been transpired in the past 100 to 150 years. Before that much scientific knowledge was spread by word of mouth, by personal letter, or by public demonstration and lectures in Universities. With a few exceptions, newspapers showed little interest and illiteracy meant that science would not be spread very far, even if the media in those days had been involved.

Over time people have realized that science communication plays a vital role in our society. Today science attracts huge media coverage, and its communication aims to enhance public scientific awareness, understanding, literacy, and culture by building AEIOU (Awareness, Enjoyment, Interest, Opinion-forming, and Understanding of science) responses in its participants. It empowers the public to attain an interest in science, a confidence to talk about it, and a willingness to engage with science.

Science communicators use scientific journals and its articles for dissemination of scientific information among the academic community for research and development work. Societal developments, to some extent, do depend on scientific journals, where first hand research results are being published. While it's true that the quality and criteria of publishing scientific journals are being changed over time, we observe that seeking information behaviour pattern is also changing rapidly. It is particularly questionable in the online environment, where professional communication among scientists and public communication, about science, are not clearly separated.

Kindly refer the two annexures, Annexures 1 & 2 [22,23], which depicts DAE's initiative towards Nation's progress by introducing "One DAE One Subscription (ODOS)", wherein the scientists and research scholars of DAE in all the Units/subunits (60 Nos.) can now access and publish their research work to National and International Scientific Journals. Further to this, The Union Cabinet, chaired by Prime Minister, Shri Narendra Modi, has approved "One Nation One Subscription, (ONOS)" a new Central Sector Scheme for providing country-wide access to scholarly research articles and journal publications. The scheme will be administered through a simple, user friendly and fully digital process. This will be a "One Nation One Subscription" facility for the government higher education institutions and R&D laboratories of the central government.

Needless to say, that these are the two great creativities for making India Atmanirbhar and Viksitbharat@2047, and scientists, research scholars and students of India should take maximum benefit out of these initiatives.

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Annexure 1: Supporting Document: DAE initiative towards Nation's Progress [22]

Department of Atomic Energy

Department of Atomic Energy inaugurates 'One DAE One Subscription'

ODOS to enable Department of Atomic Energy and all its units/subunits for Read and Publish Access to National and International Research Papers and Scientific Journals

Posted On: 29 JUL 2024 1:46PM by PIB Mumbai

The inaugural ceremony of 'One DAE One Subscription' (ODOS) took place today at Tata Memorial Hospital, in Mumbai today. ODOS is a unique idea enabling Department of Atomic Energy (DAE) & all its units/subunits (about 60) together under one umbrella for read and publish access to national and international research papers as well as scientific journals. With this initiative it is now possible to share the resources digitally and evolve collectively. DAE has signed consortium agreements with M/s. Wiley India Private Limited and with M/s. Springer Nature Group in furtherance of the same.

On the occasion of the inauguration, Secretary, DAE and Chairman AEC, Dr. A. K. Mohanty conveyed a congratulatory message to and stated, "The ODOS Transformative Agreement is a significant milestone for synergizing the read access and publishing requirements of DAE. I am sure ODOS will benefit thousands of scientists, engineers, young students of HBNI and researchers of aided institutes to have access to much larger knowledge platform and also publish in open access journals. The ODOS will later get merged with a bigger national initiative, called One Nation One Subscription (ONOS) which has been initiated by the Office of the Principal Scientific Advisor to the Government of India. ONOS is currently under various stages of implementation."

Addressing the gathering, Shri. A.K. Nayak, Head, NCPW, DAE, stated that the objective of the ODOS initiative is to make knowledge accessible to as many people as possible. ODOS a small yet decisive step towards ONOS which will in turn make knowledge accessible to everyone and lead to the cherished dream of a developed India.

Dr. Sudeep Gupta, Director, TMC, expressed that libraries are no longer brick and mortar buildings but computers. In the current era, the world lays stress on creative innovation which can only happen when we have access to the current state of wisdom in any particular field. One way to minimize repetitive research is to let everybody access the current state of science so that we move forward and don't repeat what has already been done. DEA has once again proven it is a pioneer in taking the lead and showing the way.

About ODOS

The first ODOS agreement with M/s. Wiley India Private Limited will provide access to the collection of 1353 Wiley journals including archives from 1997, to the entire DAE community. This is against the current access of 166 unique journals provided to only 12 DAE units without much increase in price. Perpetual rights will be given to all the DAE units for all the journals for the year 2024. DAE will also get the right to publish more articles in open access journals. Under this agreement Article Processing Charges (APC) have been covered.

The second ODOS agreement with M/s. Springer Nature Group will provide access to about 2,686 Springer Nature titles which includes 553 journals as Fully Open Access (FOA). The access will be provided to entire DAE as against 1752 unique journals access provided to 14 units earlier. Perpetual rights will be given to all the DAE units for all the journals for 2024. The archives from the year 1997 for the Springer titles and from the year 2012 for Nature titles will also be accessible. The agreement will also enable DAE to publish 281 articles in Springer Hybrid journals as open access without Article Processing Charges (APC).

The ODOS Transformative Agreements (TA) signed with M/s. Wiley India Private Limited and with M/s. Springer Nature Group is a significant milestone for the DAE scientific community and enable sustainable growth of science and technology. This will boost scientific morale, foster innovation, promote research and will enhance academic publications.

Annexure 2: Supporting Document: Movement towards Nation's Progress [23]

Ministry of Education

Azadi Ka Amrit Mahotsav

Cabinet approves One Nation One Subscription (ONOS)

The Prime Minister in his address to the Nation from the ramparts of the Red Fort on 15th August, 2022, had pointed out the importance of Research and Development in our country in the Amrit Kaal. He had given the clarion call of "Jai Anusandhan" on the occasion.

The NEP 2020 has also identified research as a corequisite for outstanding education and development in our country.

The establishment of Anusandhan National Research Foundation by the Government of India was a step in this direction.

In response to the vision of making India Atmanirbhar and Viksitbharat@2047, the Union Cabinet approves One Nation One Subscription scheme to provide country-wide access to international high impact scholarly research articles and journal publications to students, faculty and researchers of all Higher Education Institutions managed by the central government and state governments and Research & Development Institutions of the central government.

The initiative will open a goldmine of knowledge available in top quality scholarly journals to nearly 1.8 crore students, faculty, researchers and scientists of all disciplines, including those in tier 2 and tier 3 cities, thereby encouraging core as well as interdisciplinary research in the country

A total of 30 major international journal publishers have been included in One Nation One Subscription. All of the nearly 13,000 e-journals published by these publishers will now be accessible to more than 6,300 government Higher Education Institutions and central government R&D institutions

Access to journals will be provided through a national subscription coordinated by the Information and Library Network (INFLIBNET), an autonomous inter-university centre of the University Grants Commission (UGC) through an entirely digital process

A total of almost ₹ 6,000 crore has been allocated for One Nation One Subscription for 3 calendar years, 2025, 2026 and 2027 as a new Central Sector Scheme

One Nation One Subscription is a timely step towards establishing India in the global research ecosystem by bringing ease of doing research to the doorstep of all students, faculty and researchers in the government institutions

Posted On: 25 NOV 2024 8:43PM by PIB Delhi

The Union Cabinet, chaired by Prime Minister Shri Narendra Modi, has approved One Nation One Subscription, a new Central Sector Scheme for providing country-wide access to scholarly research articles and journal publication. The scheme will be administered through a simple, user friendly and fully digital process. This will be a "One Nation One Subscription" facility for the government higher education institutions and R&D laboratories of the central government.

A total of about Rs.6,000 crore has been allocated for One Nation One Subscription for 3 calendar years, 2025, 2026 and 2027 as a new Central Sector Scheme. One Nation One Subscription will build on and further enhance the scope and reach of the range of initiatives undertaken by the Government of India over the past decade in the domains of education, for maximizing access to quality higher education for the youth of India. This will supplement the ANRF initiative to promote research and development and foster a culture of research and innovation throughout government universities, colleges, research institutions, and R&D laboratories.

The benefits of One Nation One Subscription scheme will be provided to all Higher Educational Institutions under the management of the Central or State Government and Research & Development Institutions of the Central Government, through a national subscription coordinated by a central agency, namely the Information and Library Network (INFLIBNET), an autonomous inter-university centre of the University Grants Commission (UGC). This list covers more than 6,300 institutions, translating into nearly 1.8 crore students, faculty and researchers, who will be able to potentially avail benefits of One Nation One Subscription.

This is in line with the goals of Viksitbharat@2047, National Education Policy (NEP) 2020 and Anusandhan National Research Foundation (ANRF). The initiative will expand access to scholarly journals to a vast diaspora of students, faculty, researchers and scientists of all disciplines, including those in tier 2 and tier 3 cities, thereby promoting core as well as interdisciplinary research in the country. The ANRF will periodically review the usage of One Nation One Subscription and publications of Indian authors of these institutions.

The Department of Higher Education will have a unified portal "One Nation One Subscription" through which the institutions will be able to access the journals. The ANRF will periodically review the usage of One Nation One Subscription and publications of Indian authors of these institutions. The DHE and other Ministries having HEIs and R&D Institutions under their management shall be proactively conducting Information, Education and Communication (IEC) campaigns among students, faculty and researchers of these institutions about availability and method of access to One Nation One Subscription, resulting in improved usage of the facility across the country. The State Governments will also be requested to carry out campaigns at their level for maximizing usage of the unique facility by students, faculty and researchers of all government institutions.

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