

ISSN 2395-6216 (PRINT VERSION)
ISSN 2395-6224 (ONLINE VERSION)

Volume 8 Number 2 April - September 2018

Centurion Journal of Multidisciplinary Research



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ISSN 2395-6216 (PRINT VERSION) ISSN 2395-6224 (ONLINE VERSION)

<https://cutm.ac.in/cjmr/centurion-journal-of-multidisciplinary-research/>

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Published by:

Registrar, Centurion University of Technology and Management
R. Sitapur, Parlakhemundi, Gajapati, Odisha
Pin – 761211

Printer:

Srimandira Publication
EPF Colony, E-Block, Saheed Nagar, Bhubaneswar, Odisha 751007

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CENTURION UNIVERSITY PRESS, ODISHA, INDIA

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Centurion Journal of Multi-disciplinary Research

Centurion Journal of Multi-disciplinary Research is a refereed journal, which serves as a platform for exploring the current issues, challenges and linkages in the broad areas of development, technology, engineering and management. There is a special focus on skill development and education, its recognition and promotion in the country, especially with the 'Make in India' initiative by the government of India. The objective of the journal is to facilitate bringing together research based contributions in science, technology, management and skills that has direct implication for the development of under-privileged communities and empowering them. The journal links theory and practice in the above areas so as to have policy and programme implications, particularly in under-developed contexts. In addition to articles from individuals or collectives, the journal publishes book reviews.

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Editorial

The sustainable Agriculture (SA) practices lead to protect the environment, expand the Earth's natural resources, improve soil fertility and maintain sustainable food systems. This in turn supports to fulfill the goals of SDG 2 "Zero Hunger" and SDG 12 "Responsible Consumption and Production". The post-harvest handling of agriculture or food product is the responsibility of each person involved in food system. Many post-harvest techniques maintain the agriculture product quality without damaging the environment and human health through physical and chemical treatments. Those techniques mitigate losses and improve food safety through cold storage, refrigerated transport, pasteurization, etc. Further, Conservation Agriculture (CA) can improve crop production by enriching soil fertility leading to sustainability. This sustainable farming technique follows three practices: crop diversification, minimal soil movement and permanent soil cover. If not implemented sustainably, agriculture can harm the environment through greenhouse gas production that affects climate change. In order to reduce soil erosion, farmers adopt zero-tillage farming. The direct planting is adopted without plowing soil. Zero-tillage with intercropping and crop rotation can be an advantage, which implements either growing two or more crops simultaneously on the same land, or growing two different crops on the same land successively.

Approximately 50% of the world's total arable land area consists of acid soils. The Aluminium toxicity and Phosphorous deficiency are two prominent factors for the degradation of soil. If not cared properly, the soil will rapidly lose much of their original fertility and finally they may become barren. Once the fertility of the soil surface layer is lost, it may be too difficult for the soil to return to its former productivity in less than ten years. If the soil productivity is to be sustained, the erosion and leaching losses must be prevented through proper management of agricultural soils.

In a paper, Gagan Kumar Panigrahi has discussed the effective post-harvest techniques to be adopted in the agricultural sector to fulfill the global demands by retaining the required nutritional quality of horticultural produce. He has explained some postharvest practices including physical, chemical and gaseous treatments needed to increase their storage life with minimal quality loss, weight loss and fruit softening without damaging human health and the environment. Sasmita Panda, in a paper, has studied the rapid degradation of water bodies due to anthropogenic activities in a pond ecosystem. The Sankara pond in Sundargarh town, Odisha, is the focus of case study. The quality of the water is assessed by determining a few Physico-chemical parameters such as dissolved oxygen, pH, hardness, turbidity, salinity, temperature, BOD and COD. Lalichetti Sagar has drawn a critical review on conservation agriculture to increase crop production, soil fertility and global food security. He has proved conservation agriculture as an efficient tool in preventing land degradation and attaining higher yields. S.K. Sahoo has elaborated on the synthesis of graphene oxide by modified Hummer's method used for adsorbing highly toxic Cr(VI) ions from water. Upasana Sahoo has studied soil acidity rich in Aluminium toxicity and phosphorous deficiency that makes the soil highly infertile and barren. She has suggested that lime and organic residues will enhance the soil's nutrient content producing more yields. Subhashisa Praharaj, in his paper, has proposed a new technique for improving sugarcane productivity and quality using ethylene and gibberellic acid. A.K. Pradhan, in his paper, has examined the characteristics, selection procedure and effect of NMR solvent.

The rapid growth of industries leads to excessive heavy metal load in the environment. Graphene Oxide (GO) has recently attracted resurgent interests because of its superior properties such as large surface area, mechanical stability, and tunable electrical and optical properties. Graphene and graphene oxide are the latest and advanced materials with wide applications in the environment, medical applications, industries, defense and energy storage/conversion applications. Among many improved methods pursued over the years, modified Hummer's method is conveniently used to synthesize graphene to obtain more effective alternatives. S.K. Sahoo has discussed graphene-based metal

oxide nanomaterials for energy applications such as lithium batteries, photovoltaic/photo-electro-chemical devices, and super capacitors.

The articles for this issue in the journal contain the contemporary research mostly across the fields of agriculture. The study from all authors is very informative and valuable for more agricultural productivity, but it needs to be adapted and applied locally. For the farmers to use this, more research and extension education is required than what we have.

Dr. R. C. Mohanty
Professor

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Sustainable Agriculture through Post Harvest Treatments

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
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Gagan Kumar Panigrahi¹

Abstract

Effective postharvest techniques allow agricultural sector to fulfil the global demands by retaining the required nutritional quality of horticultural produce. To enhance postharvest quality of harvested produce, which are in a state of ripening, undergoes senescence and metabolically active must be taken care of by practicing efficient methods, otherwise it would result into significant financial loss. Effective postharvest techniques primarily focus in limiting the rate of metabolic process resulting in delay of senescence, maturation and minimizing the risk of microbial contamination. A variety of management practices including physical, chemical and gaseous treatments have been introduced. Physical treatments include irradiation, edible coatings and

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heat. Chemical treatments comprise of antioxidants, applying suitable antimicrobials. Temperature management has been a classical practice. This study focusses on the prevailing status of postharvest techniques including the use of ozone and plasma, resulting in maintaining quality and reducing loss of fresh produce.

Key words: postharvest, horticulture produce, irradiation, edible coating, plasma

I. Introduction

Horticultural produce is rich in nutrients; however postharvest they are prone to various metabolic reactions resulting in their decay. To overcome this situation, well coordination from the level of farmers up to the consumers' needs to be maintained. The level of this coordination varies, usually slack at local level and highly complex at global level depending on the ease of adopting efficient post harvesting strategies. According to the Food and Agriculture Organization, 33% of global food was wasted on the weight basis during 2009.¹ Essentially, reducing food losses is vital. Quality of fresh produce is highlighted from its flavour, texture, appearance and nutritional value. But, for safety of the consumers it is equally important to make sure that the produce is devoid of any microbial or chemical content. Essentially contamination of fresh produce with pathogens or microorganisms can lead to serious illness.² Maximum uncertainties lead to spoilage of the fresh produce, thus the role of postharvest treatments becomes critical.³ Several effective techniques including physical, chemical and gaseous techniques are introduced in order to safeguard the horticultural produce, keeping an eye on maintaining safety and nutritional standards. Maintaining appropriate temperature is equally vital and traditionally being practiced.

I. Physical treatments

I.1 Heat treatment

Heat treatment has been widely used technique which leads to decrease in chilling injury, delay in ripening primarily by inactivation of degradative enzymes, avoidance of contaminations and fungal infections.⁴ This

treatment includes hot water rinse, hot water dip and saturated water vapour heat. Duration of heat treatment can be short up to 1 hour or long ranging to 4 days. Heat treatment adds to longevity of horticultural produce. For instance, *Penicillium* sp. Causes blue mould on grapefruit and it can be restricted by simple dipping of fruit in hot water (50°C) for 2 minutes.⁵ A mixture of HF-01, sodium bicarbonate and *Bacillus amyloliquefaciens* and hot water is one of the promising techniques used to maintain quality of fruits.⁶

1.2 Edible coating

Edible coatings are essentially layers of surface coatings applied on the surface of fresh produce, primarily to enhance the safety of the fresh produce especially where the cuticle is lost.^{7,8} This act as a barrier by not allowing the movement of moisture on the surface, resulting in slowing down of respiratory rate, decreased oxidation, and protects from mechanical damages, leading to increase in quality and safety of fresh produce.^{8,9,10} Edible coatings usually contain hydrophobic groups, protein-based compounds chiefly to increase the functionality of edible coating.⁹ Also, edible coating layers add to antimicrobial activity.¹⁰

1.3 Irradiation

The basis of this technique is to desensitize the nucleic acids and proteins so as to restrict further metabolic reactions, eventually delaying the senescence.¹² Preferably, high energy electron beams, γ radiations are projected onto the surface of fresh produce, resulting in breaking of essential molecular bonds, nucleic acids including DNA and RNA. By slowing down the metabolic processes, shelf-life of fresh produce is enhanced. Though, the extent of radiation is critical as the desired effect primarily depends on the doses. Doses are measured in kilograys (kGy), low doses less than 1 kGy can only lead to the disruption of cellular activity, inhibiting sprouting of tubers, roots and bulbs. Medium doses range from 1-10 kGy effect the microbial loads and high doses ranging above 10 kGy can be an effective tool against various bacterial and fungal species.¹³ But, exposure of fresh produce to medium and high-level doses may cause defects in flavour, texture and visual. Irradiation is widely used postharvest management technique to restrict the

growth of microbes and thus bring about food safety.¹⁴ For instance, irradiation dose of 1 kGy is considered to be highly effective for enhancing shelf-life in litchi fruit.¹⁵ It is also reported that irradiated fresh produce is safe for consumption.¹⁶

2. Chemical treatments

2.1 Antimicrobial agents

In order to maintain safety of the fresh produce, various antimicrobial and anti-browning agents are used, which can be categorized into chemical and natural agents.¹⁷ Chlorine based agents, organic acids, peroxyacetic acid, electrolysed water are a few widely used agents. Again, the level of chlorine is critical to bring about required changes. NaClO is one of the commonly used oxidizing agents. But chlorine may not be the best alternative as chlorinated compounds may form carcinogenic compounds.¹⁷ PAA is also a strong oxidizing agent.¹⁸ PAA is efficient in degrading the growth of *L.monocytogenes* and *E.coli* present on many kinds of fresh produce.¹⁹ Hydrogen peroxide (H_2O_2), an oxidant possesses antibacterial, sporicidal activity.²⁰ Application of H_2O_2 extends shelf-life and facilitates in decreasing microbial populations.²¹ Organic acids, ascorbates largely slow down enzymatic reactions and restrict the growth of microbes.²²

2.2 Nitric oxide

Nitric oxide (NO) is one of the reactive gases, primarily involved in various signalling pathways in plants.²³ With the maturation of fresh produce, NO level decreases. External exposure of the horticultural produce with NO will help to compensate the endogenous loss of NO and facilitates in maintaining the shelf-life and longevity.²⁴ This also favours the fresh produce in restricting them to ripen by restricting the concentration of ethylene hormone, which would otherwise fasten the ripening phase.²⁵ NO exposure results in decline rate of respiration and water loss.

2.3 Sulphur dioxide

Application of sulphur dioxide (SO_2) prevents decay of many fresh produces. Primarily fumigation is done from the horticultural field

followed with weekly fumigation of the storage chambers.²⁶ SO₂ specifically can reduce fungal contamination over the fresh produce, though it can also initiate injuries on the surface, and it also possesses health risk. Despite of this, SO₂ treatment is widely used as a postharvest method to increase the longevity.

3. Gaseous treatments

Several gaseous agents are used in order to restrict the fresh produce from decay and to increase the sustainability, longevity and quality by removing the hazardous agents. An overview on gaseous treatments is listed in Table I.

Treatments	Benefits	Example of application
Ethylene	Initiates ripening thus enhances fruit coloration and quality	Tomato, banana, persimmon, avocado, kiwifruit, mango and citrus fruits. ²⁷⁻³⁰
Ozone	Easy incorporation into cold storages, washing system, better efficiency as compared to chlorine	Apples, cherries, carrots, garlic, kiwi, onions, table grapes. ³¹⁻³⁴
1-Methylcyclopropene	Maintains integrity of the cell wall and coloration, develops aroma and flavour	Broccoli, cucumber, date, kiwifruit, mango, melon, nectarine, papaya, peach, pear, pepper, persimmon, pineapple, plantain, plum. ³⁵⁻³⁸
Modified atmosphere packaging	Delay in senescence by slowing down respiration and rate of decay	Cherries, carrots, fresh-cut fruits, leafy green vegetables. ³⁷⁻⁴⁹
Controlled atmospheric storage	Retards senescence and metabolic reactions, resulting in delay in severity	Avocado, strawberry, cherry, cabbages, kiwifruit, avocados, persimmon, pomegranate, asparagus, banana. ⁴⁰⁻⁴²

Table I. List of various gaseous agents for post-harvest treatment of fresh produce

4. Plasma

Plasma is considered to be one of the best methods specifically in decontaminating horticultural produce. Plasma mainly comprises of ionized gas molecules, dissociated by an input source of energy. Based on the activation energy, high or low temperatures commonly referred to as thermal or cold plasma is generated.⁴³ Cold plasma is generated by transforming argon gas to plasma by using radio frequency energy waves.⁴⁷ In order to achieve effective decontamination, microorganisms need to be eliminated at DNA level, which is achievable by the optimum usage of cold plasma.⁴⁴ More detailed studies are required to improve the efficacy of this technique.

Conclusion and future perspectives

Various strategies are employed to extend the shelf-life and quality of the horticultural produce. Primarily, specific techniques are applicable to certain kinds of products, thus efficiency of postharvest techniques needs to be closely monitored in order to be effective against broad spectrum of hazardous agents. Appropriate application of mixed techniques can be effective in restoring the nutritional and physical attributes, mostly by delaying the decay processes. Advanced technologies based on application of ethylene inhibitors, chemical modulators for delay in ripening are emerging. Use of nanotechnology in the field of postharvest management is also promising. Developing nanocomposites with an aim to control microbial growth and/or to release specific agents into the fresh produce would be of great use. Studies on various aspects of devising and delivery systems will help to elevate the efficiency of postharvest technologies.

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Determination of Physico-chemical Parameters of Community Pond

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
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Sasmita Panda¹

Abstract

A pond ecosystem is characterized by relatively quiet water and abundant vegetation. It is a small area of still, fresh water. The present investigation was carried out in Sankara pond which is present in the heart of Sundargarh town, Odisha. The pond is home to many water birds, local as well as migratory. Due to anthropogenic activities there is rapid degradation of water bodies. Hence bioremediation is required in order to restore the affected water bodies. The study was carried out in winter season from 01st November, 2016 to 31st December, 2016. The value of most of the physico-chemical parameters of water are in desirable limit except the BOD (6mg/l) value which exceed the normal limit which indicates the enrichment of water due to the uncontrolled dumping of garbage, debris and sewage. The pH of the water was found to be between 6.87 to 9.05, the conductivity was between 344 to

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470 μ S, the salinity was between 0.22 to 0.24ppt, the turbidity was between 1.55 to 2.33 Nephelometric Turbidity Units (NTU), the TDS was between 200ppm to 218ppm and the total hardness during the study period was 100mg/l, the calcium and magnesium value was 20.84 mg/l and 11.66 mg/l respectively. The water quality of the Sankara pond was moderate for aquatic organisms, for aquaculture and agricultural uses; though it is moderate for aquatic organisms it needs to be restored because of the increase in BOD level.

Key Words: Limnology, sankara pond, physico-chemical parameters, Zooplankton, water birds.

Introduction

Water is a vital component necessary for life without it, there is no life. In recent time limnology plays an important role in water use and distribution as well as in aquatic habitat protection. A basic feature of earth is abundance of water, which extends over 71% of its surface to an average depth of 3800m.¹⁻⁶ About 97% of the total water available is salt water and the remaining 3% is freshwater.⁷⁻¹² Water resources are declining day by day due to increase in population which result in increasing urbanization. Deterioration of the water quality is now a global problem.¹³⁻¹⁹ The purity of water varies from place to place in nature.²⁰⁻²³ The quality of water of any aquatic ecosystem arises by the intercommunication of chemical, physical and biological component. Pond as an ecosystem is characterized by relatively quiet water and abundant vegetation.²⁴⁻²⁸ The important components of pond ecosystem are as follows:

Abiotic components: The abiotic component of a pond ecosystem includes all the non-living molecules such as water, oxygen, carbon dioxide, calcium, magnesium, potassium etc.

Biotic components: The biotic component of pond ecosystem includes the living organisms they may be producer (phytoplankton and macrophytes), consumer (zooplankton, fishes, and waterfowl) and decomposer (microorganisms).

Sundargarh is a district in the north-western part of Odisha state in eastern India. The district has a sub-tropical climate and intensity mildly extreme. The Sundargarh district lies between 21.47'7" to 22.32'2" N latitude and between 83.32'19" to 84.34'18" E longitude. All the 17 blocks of the district has various water bodies, viz. ponds, reservoirs, streams, wells, paddy fields and river. Sankara pond is situated in the heart of the city. It is an important wetland which is home to resident and winter visitor avifauna. The bird density were more in winter season rather than other seasons as there was optimum water storage, availability of abundant food, increase vegetation and the arrival of migratory birds. The waterfowl population and distribution in the Sankara pond is regulated by invertebrates and the wetland birds largely feed on a wide range of the invertebrate community and small fishes.

Materials and Methods

Study area

Selected pond is situated in the heart of the city, Sundargarh, Odisha. The samples were collected from five different Ss, enough to assess their physical and chemical and biological parameters at alternate days in the winter season. Before the collection of sample the containers were rinsed with distilled water to avoid contamination for the analysis of physico-chemical properties and zooplankton. Water samples were collected in sampling bottle avoiding floating materials.²⁹ The cap of the sample containers were closed properly to prevent outside contamination. The container was labeled describing the date, time and sampling S. Different physico-chemical parameters such as color of water, odor, taste, air temperature, water temperature, pH, dissolved oxygen, conductivity, salinity, total dissolved solid were measured by Systronics water analyzer 371, whereas the analyses of remaining parameters like BOD, COD, total hardness, calcium, magnesium and free carbon dioxide were determined.³⁰⁻³³ The species assemblage of Zooplankton is useful in assessing water quality. Zooplankton was collected using plankton net and the collected samples were preserved in 5% formalin. The preserved sample was brought to laboratory for analysis. Quantitative studied were made by using Sedgwick rafter cell.

Zooplankton were identified.^{34,35} The macrophytes and fishes found in the pond were also observed and recorded. The aquatic birds and other terrestrial birds present around the study area were also observed with the help of binoculars, recorded and identified using photographic field guide to “Birds of Sundargarh Forest Division”.

Results and Discussion

Table 1. Water color during winter season at different Ss of study.

S-1	S-2	S-3	S-4	S-5
Clear (greenish)	Clear (greenish)	Clear (greenish)	Clear (greenish)	Light muddy (light muddy)

During the study period the weather condition was bright. (S: Site)

Air and water temperature

Table 2. Variation in air temperature during winter season at different sites (S) of study.

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	±S.D
27.1	26.8	26.4	27.4	26.9	26.4	27.4	26.92	0.331
19.3	19	18.6	19.2	19.4	18.6	19.4	19.1	0.282
24.2	24.3	23.8	23.4	24.3	23.4	24.3	24	0.352
23.1	22.9	22.5	23.2	23.4	22.5	23.1	23.02	0.305
26.3	26.7	25.6	26.1	26.5	25.6	26.7	26.24	0.377

Table 3. Variation in water temperature ($^{\circ}\text{C}$) during winter season at different sites (S) of study.

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	\pm S.D
21	20.3	19.8	20.4	20.1	19.8	21	20.32	0.3969
13.1	12.9	11.9	13	13.2	11.9	13.2	12.82	0.4707
16.9	17	17.2	17.1	17.1	16.9	17.2	17.2	0.1732
17.2	17	16.8	16.8	17.2	16.8	17.2	17	0.1788
19	18.1	18.3	18.1	18.2	18.1	19	18.34	0.338

The minimum and maximum ambient temperature of Sankara pond ranges from 19°C to 27°C and the water temperature varied from 13°C to 21°C during the study period.

pH

Table- 4. Variation in pH during winter season

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	\pm S.D
9.05	7.9	7.25	7.52	6.97	6.97	9.05	7.684	0.56887
8	7.4	7.1	6.9	6.88	6.9	8	7.256	0.41634
9.05	7.9	7.58	7.37	6.95	6.95	9.05	7.77	0.71046
8.37	7.42	7.24	7.36	6.87	6.87	8.37	7.452	0.4971
9.03	7.45	7.65	7.48	6.85	6.85	9.03	7.692	0.7217

The pH value recorded ranges from 6.87 to 9.05. The highest value of pH was recorded from the S-I and the lowest was recorded from S - 5. The low pH value indicates that the slightly acidic nature of the pond

water and high pH basic nature of the water. The pH value affects most of the biological processes and biochemical reactions in water body (Arya et al., 2011)

Electrical conductivity

Table-5. Variation in conductivity ($\mu\text{S}/\text{cm}$) during winter season

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	$\pm\text{S.D}$
450	346	365	350	345	345	450	371.2	40.0469
445	356	370	365	365	356	445	380.2	32.7133
470	355	359	364	375	355	470	384.6	43.22314
420	346	344	356	345	344	420	362.2	29.2191
435	345	350	370	350	345	435	370	33.6154

Conductivity values depend on the nature of the various ions present in the water sample, their relative concentrations and the ionic strength. Conductivity recorded in Sankara pond range from $344\mu\text{S}$ to $470\mu\text{S}$. The high value of conductivity was recorded in S 1 and the low value was recorded in S 5.

Salinity

Table-6. Variation in salinity (ppt) during winter season

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	$\pm\text{S.D}$
0.22	0.22	0.22	0.23	0.23	0.22	0.23	0.224	0.0048989
0.23	0.22	0.23	0.23	0.24	0.22	0.24	0.23	0.00632455
0.22	0.23	0.23	0.23	0.24	0.22	0.24	0.23	0.006324
0.22	0.23	0.23	0.23	0.23	0.22	0.23	0.228	0.004
0.22	0.22	0.23	0.22	0.23	0.22	0.23	0.224	0.00489

In the Sankara pond the amount of salinity recorded ranges from 0.22 ppt to 0.24 ppt. The maximum value of salinity was recorded in S 5 and the minimum value was recorded in S1.

Total dissolved solid

Table-7. Total dissolved solid Variation in TDS (mg/l) during winter season

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	±S.D
215	205	202	211	212	202	215	209	4.7749
218	204	204	209	215	204	218	210	5.692
216	203	200	207	210	200	216	207.2	5.5641
218	208	206	214	214	206	218	212	4.3817
217	207	203	210	211	203	217	209.6	4.6303

The solids present in water in the dissolved state are known as total dissolved solids. In the Sankara pond the amount of total dissolved solid recorded ranges from 200 ppm to 218 ppm. TDS values in ponds, Lakes and streams are typically found to be in the range of 50 to 250 ppm.

Turbidity

Table-8. Variation in turbidity (NTU) during winter season

S-1	S-2	S-3	S-4	S-5	MIN	MAX	MEAN	±S.D
1.57	1.55	1.64	1.56	2.33	1.55	2.33	1.73	0.30166

Suspension of particles in water hindering with passage of light is called turbidity. Turbidity in Sankara pond ranges from 1.55 NTU to 2.33 NTU. The high value was recorded in S 5 as the water was light muddy.

Total hardness

The hardness causing ions in water are mainly calcium and magnesium and are the measure of the capacity of water to react with soap. The amount of hardness in the water of Sankara pond recorded was 100mg/l.

Calcium and magnesium

Both the calcium and magnesium ions present in water cause the hardness of water.

The observed value of calcium in Sankara pond was 20.84mg/l and the observed value of magnesium was 11.66mg/l.

BOD

Biological oxygen demand (BOD) is the amount of oxygen required by microorganism for stabilizing biologically decomposable organic matter in water under aerobic conditions. The observed value of BOD in Sankara pond was 6mg/l. As BOD exceeds 3mg/l, hence the water of the Sankara pond need water treatments.

COD

Chemical oxygen demand (COD) is the measure of oxygen equivalent to the organic content of the sample that is susceptible to oxidation by a strong chemical oxidant. The observed value of COD in Sankara pond was 20 mg/l.

Zooplankton

Table-10. List of some common zooplankton recorded in Sankara pond

- Zooplankton type**
- PROTOZOA**
01. *Amoeba sp.*
 2. *Arcellagibbosa*
 3. *Paramecium caudatum*
- ROTIFERA**
4. *Brachionuscalcyflorus*
 5. *Brachionusforicula*
 6. *Asplanchnapriodonta*
 7. *Filinalongiseta*
- CLADOCERA**
8. *Daphnia carinata*
 9. *Moinamicrura*
- OSTRACODA**
10. *Cypris sp.*
 11. *Centrocypris sp.*
- COPEPODA**
12. *Diaptomuswierzeskii*
 13. *Mesoclops sp.*

Zooplankton considered being the ecological indicator of water bodies. Physico-chemical parameters, light intensity, food availability, and predation effect the population dynamics of zooplankton. Low pH or high salinity can reduce their diversity and density. In the present investigation the diversity of zooplankton were represented by Rotifera, Protozoa, Cladocera, Copepoda and Ostracoda.

Macrophytes

Macrophytes in an aquatic ecosystem are particularly important as they are the producer and are responsible for photosynthesis and they

provide habitat for many smaller aquatic organism as well as feeding and breeding ground for many fishes by supporting many invertebrate species which take shelter among the macrophytes and also for the water birds. The dominate species of macrophytes present in Sankara pond are *Nymphaeaurubra*, *Elodea sp.*, *Hydrilla sp.* and *Marsilea sp.*

Fishes

Table 11. List of some common fish species recorded in the Sankara pond

Sl No.	Common name	Scientific name	Family	Order
1.	Striped snakehead	<i>Channa striatus</i>	Channidae	Perciformes
2.	Spotted snakehead	<i>Channa punctatus</i>	Channidae	Perciformes
3.	Magur	<i>Clarius batrachus</i>	Clariidae	Siluriformes
4.	Climbing perch	<i>Anabas testudineus</i>	Anabantidae	Anabantiformes
5.	Scarlet-banded barb	<i>Puntius amphibius</i>	Cyprinidae	Cypriniformes

A comprehensive knowledge of the limnological features of any aquatic environment in which fish live is vital for assessing its productivity and suitability for rearing fish. Biological production in any aquatic body gives direct correlation with its physico-chemical status which can be used as trophic status and fisheries resources potential.³⁶⁻⁴⁰ The dominate fish species present in Sankara pond were *Channa striatus*, *Channa punctatus*, *Clarius batrachus*, *Anabas testudineus* and *Puntius amphibius*.

Study of different types of fish is important not only for ecological balance but also for meeting the need for food. It is necessary to record the information about various fishes located at different regions. Proper utilization of fishes can address the issues of malnutrition among people of under developed countries. Appropriate study and use of fishes can take care of SDG 2, SDG 3 and SDG 14.

Avifauna

Table-12. List of bird recorded around the Sankara pond

SI No.	Common name	Scientific name	Family
1.	Little Grebe	<i>Tachybaptusruficollis</i>	Podicipedidae
2.	Little Cormorant	<i>Phalacrocoraxniger</i>	Phalacrocoracidae
3.	Little egret	<i>Egrettazarzetta</i>	Ardeidae
4.	Cattle egret	<i>Bubuusibis</i>	Ardeidae
5.	Indian pond heron	<i>Ardeolagryii</i>	Ardeidae
6.	Lesser whistling duck	<i>Dendrocygnajavanica</i>	Anatidae
7.	Norther pintail	<i>Anasacuta</i>	Anatidae
8.	White breasted waterhen	<i>Amauornisphoenicunus</i>	Rollidea
9.	Common coot	<i>Fulicaatra</i>	Rollidea
10.	Bronze winged jacana	<i>Metopidiusindicus</i>	Jacaniidae
11.	Pheasant tailed jacana	<i>Hydrophasianuschirurgus</i>	Jacaniidae
12.	Lesser coucal	<i>Centropusbengalensis</i>	Cuculidae
13.	White throated kingfisher	<i>Hayonsmyrnensis</i>	Alcedinidae
14.	Indian roller	<i>Coraciasbenghalensis</i>	Coraciidae
15.	Paddy field pipit	<i>Anthusrufulus</i>	Motacilladea
16.	Purple moorhen	<i>Porphyrioporphy rio</i>	Rallidae
17.	Gadwall	<i>Anus strepera</i>	Anatidae
18.	Cotton teal	<i>Nettapuscoromandelianus</i>	Anatidae
19.	Black drongo	<i>Dicrurusmacrocercus</i>	Dicruridae
20.	Little green bee eater	<i>Meropsoorientalis</i>	Meropidae
21.	Cinnamon bittern	<i>Lxobrychuscinnamomeus</i>	Ardeidae

Wetland provide an important habitat for feeding and breeding for many species of aquatic birds. Many species of birds are highly adapted to live in water bodies. During the course of the present study, the bird species encountered were also recorded. A total of 22 species belonging to 14 family were recorded.

Conclusion

From the present study it is concluded that limnological study is very useful to get a fairly accurate idea of quality of the water by determining a few physico-chemical parameters. From the study it is reveal that all the physico-chemical parameters of the pond are within the desirable limit except the BOD value. The BOD exceeds the normal value because of the flow of fertilizer from the agricultural land surrounding the pond hence required water treatment. As all the physico-chemical parameters are under desirable limit so, the water of Sankara pond is moderate for aquaculture, bathing and agricultural uses.

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Conservation Agriculture-A way towards Sustainable Crop Production

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
Odisha, India

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Abstract

Green revolution ensured global food security stressing on intensive cultivation and introduction of high yielding varieties. Although during the early stage of adoption clean cultivation was seemed to be an ideal option to provide competitive advantage to crop and helped in attaining higher yield. However, with time significance of clean cultivation was deteriorated. Besides the realized yield improvement from green revolution became static. Thus, focussing on a paradigm shift towards a sustainable production system is highly essential to ensure sustainable food production. In this context to feed the rapidly increasing population conservation agriculture is emerging as an alternative and environmentally safe approach. This system basically involves minimum or no tillage, maintain at least 30 per cent of crop residues on the soil

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surface as a soil cover and involves crop diversification with legumes. In this review, conventional agriculture when compared with adoption of conservation agriculture it was identified as an efficient tool in preventing degradation of land and attain sustainability in agriculture.

Keywords: Conservation Agriculture, Soil organic carbon, Zero tillage, Infiltration

I. Introduction

Globally, rapid expansion in population raised the demand for food, fibre. To cater to this heavy demand there is an urgent requirement to raise global food production.¹ On the other hand the cultivable land is shrinking with the surge in population pressure limiting the scope to increase the area under the plough.² A paradigm shift towards the identification and adoption of feasible technologies and principles is of paramount importance to achieve sustainability in agriculture.³ Although clean cultivation was beneficial initially but upon intensifying tillage operations without adequate application of organic matter, it elicits decomposition and rapid loss of soil organic carbon.⁴ Further, this exhaustion leads to poor soil physicochemical and biological properties of soil. This might hamper food security and act as a hurdle in realizing the goals of sustainability over the long run. In this context, conservation agriculture is an emerging alternative to conventional crop production.⁵

Conservation agriculture is a residue management system that is primarily involved in the conservation and emulation of different natural resources in a sustainable manner.⁶ Conservation agriculture is based on three principles which are considered to be three legs upon which the system is based.⁷ The three principles of conservation agriculture are minimum manipulation of soil for cultivation, efficient residue management to establish a permanent mulch layer on the soil surface and legume-based diversified crop rotation.^{8,9}

Over the long run due to high reliance on biological tillage it is reported to minimize the soil compaction and be concerned with organic matter build-up in the soil.¹⁰ Similarly, with the limited disturbance to the soil weed bank was destined to exhaust over time. Further, this is energy

efficient and economically profitable approach as this system involves trimming several unnecessary agricultural operations aiming to save a lot of energy in this process.¹¹

In the light of the above facts in this paper, we summarized the impact of conservation agricultural systems on soil properties, carbon sequestration, adaptation/mitigation to climate change, and water use efficiency. Hence, provides a comprehensive understanding of all the prospects of conservation agriculture in achieving sustainable food production.

Fig 1: Principles of Conservation Agriculture



2. Impact of Conservation Agriculture on Soil Physical Properties

The role of conservation agriculture on soil physical properties was mainly attributed due to its impact on organic matter balancing in the soil. The soils with no or very little aggregates will be small when moist and that structure will be so weak and these fine aggregates clog the pore thereby limiting both infiltration and seedling emergence.¹² Reduced tillage and increased residue cover on the soil played a significant role in adding organic matter into the soil.¹³ However, this enhancement in organic matter concentration in the soil was realized

in a long run and due to minimum disturbance of soil and addition of residue cover boosts microbial population in the soil and this upon slow decomposition the organic matter builds up in the soil and later this organic matter helps in binding the soil aggregates one to the another and thus imparts stability to aggregates and attributes an improved soil structure, respectively.^{14,15}

This improved structure and stabilized aggregates due to conservation agriculture further attribute a higher infiltration rate. In addition, this also supports enhanced retention of moisture from the infiltrated water.¹⁶ Moreover, the crop residues on the surface protect the soil from the direct impact of raindrops which facilitates reduced soil erosion and reduces the evaporation from the surface. Although initially soils under conventional tillage positively impacted the infiltration due to increased traction of heavy machinery on the soil in a long run it was reported to increase soil compaction, and thus this role of conservation agriculture could attribute towards sustainability.¹⁷

Soil porosity was positively impacted due to improved soil physical properties. This helps in enhanced soil aeration.¹⁸ Although bulk densities were reported to be higher under no till/ minimum tillage field but still this will not limit root penetration and crop growth and with repeated sowing under conservation agriculture due to accumulation of residues in the soil surface the bulk densities reported to show a declining trend.¹⁹ In a study conducted in Zambia in soyabean indicated that significant difference in bulk density was observed in conservation agriculture after 16 years over conventional tillage, comparatively (Table 1).²⁰

Table 1: Impact of conservation agriculture on soil bulk density (g/cm³)

Sampling time	4years	7 years	16 years
Conventional Tillage	1.42	1.32	1.36
Conservation Agriculture	1.38	1.27	1.14
CD @ 5%	0.1001	0.1423	0.0001

3. Impact of Conservation Agriculture on Soil Chemical Properties

In general, the areas adopting conservation agriculture practices were observed to be acidic in their reaction. This was mainly due to organic acids accumulation under the conservation agricultural system on the soil surface.²¹ Organic acids were either accumulated from root or microbial exudates thus playing a key role in modifying the reactive properties of the soil.²² Indirectly, this phenomenon thereby influencing the nutrient uptake of various nutrients and simultaneously governing the associated losses. Although the magnitude of change in soil reaction depends on the buffering capacity of the soil such that the rate of change pH was less with the increase in buffering capacity and vice versa.²³

Positive correlation of conservation agriculture with soil organic carbon build-up in the soil significantly influencing its role in nutrient availability in plants.²⁴ Conservation agricultural practice is reported to add a sufficiently high amount of residues attributed to increasing the nutrient storage capacity in the soil.²⁵ If those residues leftover were with wider C:N ratio then due to more carbon availability it supplies energy to increase the population of decaying micro-organisms and consequently leading towards temporary immobilization of soil available nitrogen due to deficiency in the residues added. Similarly, if residues were of a narrow C:N ratio this problem of temporary immobilization never occurs.²⁶

On the other hand, in arid areas due to adoption no-tillage the nutrients releases upon mineralization from the residues will lie on the surface and upon severe evaporation of surface moisture, this would consequently hamper the nutrient availability.²⁰ Similarly, in humid areas with more rainfall, as the areas under conservation agriculture are less compact and facilitate better infiltration hence the mobile nutrients released might be subjected to excessive leaching losses rendering them unavailable when the water carries away the nutrients beyond the root zone.¹⁸

4. Impact of Conservation Agriculture on Soil Biological Properties

The soil under the crop residual cover is more conducive for the growth and development of soil microbes. Enhanced retention of soil moisture and limited exposure to sunlight ensures favourable conditions

for the rapid increase in the rate of microbial multiplication.²⁷ Moreover, this system also provides moist and humid micro-climate and strongly has a regulatory influence the soil temperature. In comparison, due to the rich source of carbon acquisition within the conservation agriculture system over conventional farming facilitates the development of microbial biomass. The crop diversification principle associated with this system triggers the crop-based associated interactions and consequently leads to the establishment of diversified soil microbial biomass.²⁸ A study indicated that conservation agriculture practice viz. zero tillage + residue retention realized higher organic matter content over convention agriculture practices in comparison which was associated due to slow decomposition in zero tillage. Consequently, providing energy for the build-up of biomass in soil micro-organisms and its activity.²⁹

The diversity in the microbial availability plays an important role in providing different enzymes, exudates thus modifying the physio-chemical properties of soil that positively aim to influence plant growth and development.³⁰ Besides, moist soil and low soil temperature boosted the population's several disease-causing pathogens. Enhanced prevalence of disease with conservation agriculture was mainly occurred due to the presence of leftover crop residues. These residues serve as a host during the non-cropping season upon which they are retained and resurge with the establishment of new crop resulting in a variety of diseases.³¹ However, although this occurs initially due to the involvement of crop diversification, this effect was negligible or not significant. This might be due to increased diversity in crop cultivation brings in diversity in microbial population which will thereof help in suppressing the pathogens.

Minimum tillage operations involved in conservation agriculture realized a significant influence on soil macrofauna.³² The macrofauna in the soil mainly includes earthworms, beetles etc. These macro-fauna members have a habit of burrowing inside the soil and thereby attribute towards better soil infiltration and aeration. During intensive cultivation, this macrofauna was subjected to wear and tear due to the impact of heavy machinery. Besides, tillage may also bring up this macro-fauna from their hiding habitat and exposes them to the outer atmosphere subjecting them to predation.³¹

5. Challenges in Conservation Agriculture

Although conservation agriculture has realized to possess the potential in attaining sustainability with its ability to improve soil properties, minimize the cost of cultivation, and yield enhancement over the long run.²⁵ However, during the early stage of conservation agriculture adoption, controlling pests and diseases under no-till is very difficult and the immobile nutrients will render unavailable resulting in poor nutrient uptake and hard crust forms hinder the proper seed germination and seedling establishment. As our country is abundant with resource-poor farmers hence with the unavailability of seeding equipment seeding would be very difficult to be adopted.¹⁶

In addition, with the requirement of special seeding equipment and requirement of herbicides (non-residual) primarily involves the requirement of high capital requirement and socially, adoption of no-tillage by farmers is very difficult as clean cultivation was believed as one of the important parameters for successful crop production from their ancestors.³²

To overcome these challenges farmers needed to be educated about the benefits of conservation agriculture and institution need to give them incentives and subsidies to purchase the equipment required for conservation agriculture.³⁰ Extension activities in this regard need to be pedalled up involving method and result demonstration to build up confidence and enthusiasm towards this system.

6. Conclusion

This review clearly highlighted the impact of conservation agriculture on different soil properties associated mainly with the increase in soil organic carbon. Enhanced carbon sequestration in the form of soil organic carbon highlighted the role of conservation agriculture in this changing climatic scenario. Long term realized benefits of conservation agriculture like increased soil infiltration, building up of healthy soil with reduced soil physical limitations etc widened its scope and ultimately attributed to gain popularity as an emerging way to attain sustainability.

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Synthesis of graphene oxide by modified Hummer's method and applied for the removal of Cr(VI) ions from water

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
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Abstract

Carbon based materials are received much more attraction in the field of environmental clean-up. Among them graphene oxide (GO) is widely used for removing different inorganic and organic contaminates due to very high surface area, nontoxic in nature and containing various functional groups. Therefore, in present study, GO was synthesized using less toxic improved Hummer's process and used for adsorbing highly toxic Cr(VI) ions from aqueous solution. The as prepared GO was characterized by various analytical methods. The XRD results were confirmed the successful synthesis of GO from graphite powder. From the FTIR data, it was confirmed the existence of various oxygen containing groups in GO. The sheet like morphology was found from FESEM image. A batch adsorption method was used to estimate the removal of Cr(VI) ions from water. The sorption process was pH dependent.

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Key words: Graphene oxide, Adsorption, Chromium, environmental clean-up

I. Introduction

Carbon based materials with high surface area have been found to be one of the most attractive and active materials toward environmental treatment. Among different carbon based materials (like carbon nanotubes, nano diamonds, fullerenes), graphene and its derivatives were more widely studied because of their nontoxicity and biodegradability nature.¹⁻³ It has 2D sp^2 carbon lattice with high surface area, good chemical and mechanical stability.⁴⁻⁶ Therefore, graphene is used in various applications in all fields. Graphene Oxide (GO) is an oxidized derivative of graphene. GO have various surface-active groups like epoxy, hydroxyl, and carboxyl and these groups and increase the surface binding sites. Hence GO is a good materials for various environmental applications like photocatalysis, adsorption and filtration.^{1,2,7}

Among various environmental problems, discharge of contaminated water is more significant because of various industrial, household, municipal and agricultural water.⁸ Water infected by various pollutants such as organic (dyes, medicines, pesticides, phenol compound) and inorganic (heavy metals, anionic radical and fluoride) is a major problem to achieve a healthy environment.⁹⁻¹³ Among all pollutants, chromium (Cr) is extremely high toxic metal and very commonly present in surface and ground water. The main source of Cr in water is the discharging of waste water from paint, plastic, metal refining, cloth and fabric industries. Consumption of Cr in drinking water (more than 0.05 mg/g) is carcinogenic to ecosystem and human being.¹⁴ There are several health hitches cause by using the Cr containing water. In solution, Cr mainly presences in Cr(VI) and Cr(III) oxidation states. Out of two oxidation states, Cr(VI) is carcinogenic to human being due to smaller size, high oxidizing properties and high solubility.¹⁵ Hence there is urgent need to develop a suitable low-cost method for removing Cr(VI) ions. Adsorption method is widely used because of its simple set-up, low cost and easy to handle. For adsorption process a highly efficient adsorbent materials are required. Among various adsorption, GO is

achieved very high adsorption capability due to very high surface area and more surface-active sites to bind the different pollutants.

Hence, the main aim of this work was to synthesize GO from graphitic powder. Then the prepared material was characterized by XRD, FTIR and FESEM to analyze the formation, functionality and morphology and used for Cr(VI) adsorption.

2. Experimental part

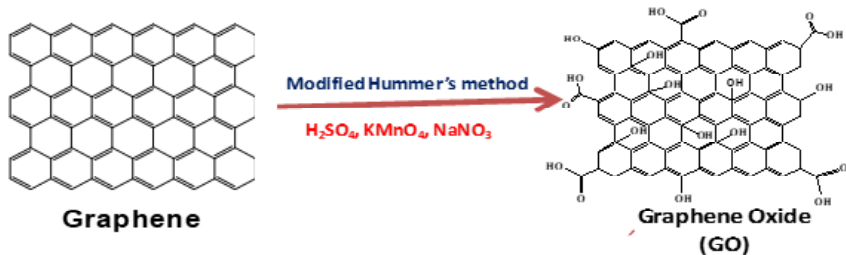
2.1. Chemical

Graphitic powder was bought from Himedia (India). Ethanol (C_2H_5OH), NaOH, 30% conc. HCl, $K_2Cr_2O_7$, 1,5-diphenylcarbazide (DPC), $KMnO_4$, H_2O_2 , conc. H_2SO_4 , 98% and acetone were collected from Merck (INDIA). All of the below mention chemicals were used as such. A standard 1000 mg/L concentration of Cr(VI) solution was prepared by adding $K_2Cr_2O_7$ in distilled water (DW). The required Cr solution was arranged by dilution the stock solution.

2.2. Preparation of GO

Customized Hummer's technique was used to synthesis of GO. The starting precursor material was graphite powder. In this method, 2g each of $NaNO_3$, graphite was mixed with 50 mL of conc. H_2SO_4 at 2-3 °C. The mixture was stayed in a stirring condition for 2h. Then 6 g of $KMnO_4$ was added. After that the mixture was refluxed at 98 °C for 12h in stirring condition. The mixture was cooled and added 75 mL of DW. Again 25 mL of H_2O_2 was also mixed in the reaction mixture. Then it was washed a number of times with DW followed by alcohol and separated the solid residue using centrifuge machine. The black color solid was dried at air oven to obtain GO. The synthetic route is also shown in Fig. 1.

Fig. 1. Synthesis of GO by modified Hummer's method



1.1. Cr(VI) adsorption experiments

In order to investigate the removal of Cr(VI), the adsorption experiments were performed by altering pH from 2 to 9. During the adsorption process we have used 0.05g of GO in 100 mL of 50 mg/L concentration of Cr solution. For the adsorption process, we have used blue capped glass bottles. After adsorption experiment, the GO was detached out using a centrifuge. Then the adsorbent free solution was collected for analysis using DPC method[15]. The %removal (%R) of Cr was determined by equations 1.

$$\%R = \frac{(C_0 - C_t)}{C_0} \times 100 \quad (1)$$

C_0 (mg/L) = Initial Cr(VI) concentration and

C_t (mg/L) = Final concentration at time t

3. Results and discussion

3.1. Characterization

Fig. 2a reveals the XRD patterns of GO. The peak at $2\theta = 10.85^\circ$ was confirmed the formation of GO from graphite powder. Fig. 2b shows

the FTIR of GO. From this image, the peak at 3468 is due to stretching vibration of O-H group. Similarly the peaks at 1730, 1620, 1430 and 1050 cm^{-1} are ascribed due to oxygen containing groups.^{14,15} This is again confirmed the complete oxidation of graphite to GO by Hummer's method. The morphology of GO is analyzed by FESEM and shown in Fig. 2c. The image showed the layer sheet like surface of GO.

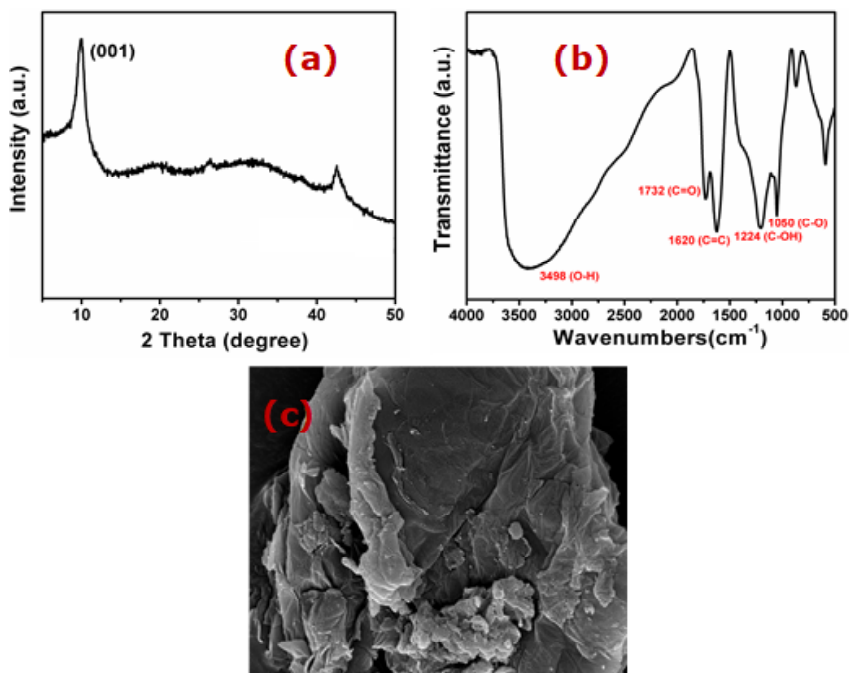


Fig. 2. (a) XRD pattern, (b) FTIR spectrum and (c) FESEM image of GO

3.1. Adsorption studies of Cr(VI)

The pH of the Cr(VI) solution is a significant parameter. Therefore, the effect of pH on Cr(VI) adsorption was executed at various pH value from 2 to 9. The obtained results are presented in Fig. 3. From the image, it is observed that, the adsorption more efficient in acidic medium.

The %R of Cr(VI) is found to 97% at pH=4 and hence it is considered as a suitable adsorbent for Cr(VI) ions from water.

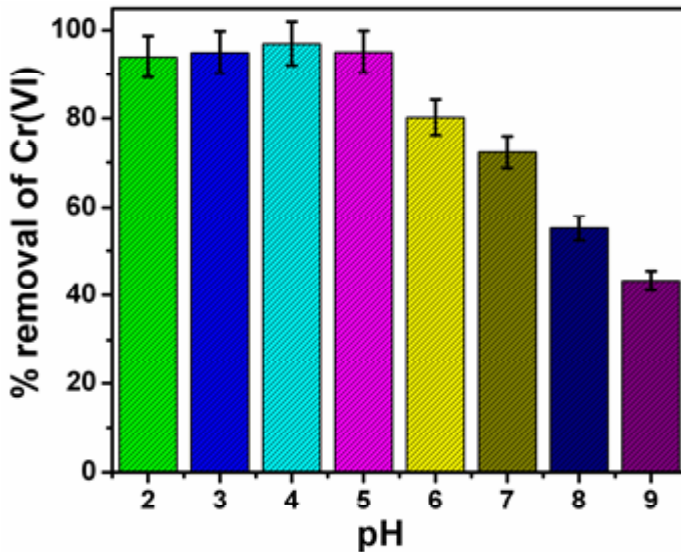


Fig. 3. %R of Cr(VI) at different pH on GO surface

3. Conclusions

GO was successfully prepared using less toxic customized Hummer's technique from graphitic powder. The prepared GO was characterized by XRD, FTIR and FESEM to analyze the phase formation, functionality and surface morphology. The XRD results were confirmed the formation of GO. From the FTIR data, it was confirmed the presence of various functional groups like epoxy, hydroxyl and carboxyl on the GO surface. The sheet like morphology was found from FESEM image. A batch adsorption method was used to estimate the removal of Cr(VI) from water by GO. The Cr(VI) adsorption process was pH dependent and maximum adsorption achieve at pH=6. GO can easily remove 97% of Cr(VI) from water containing concentration 50 mg/L. Hence, GO consider as a better adsorbent for removing Cr(VI) from water.

Acknowledgement

Very much thank to NIT, Rourkela for providing research facilities.

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Graphene based Metal Oxide Nanomaterials for Energy Applications

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
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S K Sahoo^{1,2} and M K Sahu¹

Abstract

Carbon materials, arising out of their high specific surface areas have attracted a great deal of recent research attention and have been effectively used for environmental and energy applications. Graphene and its derivatives like GO and rGO, are 2D planar sheets made up of carbon structure is gaining much recent research interest in the field of materials science and technology due to its exceptionally high surface area, remarkable physicochemical properties, thermal and chemical stability, non-toxicity, and biodegradability. Therefore, this graphene based carbonaceous materials are found to be most fascinating advanced materials and hence used worldwide for various applications including energy-based applications like lithium battery, photovoltaic/

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photoelectrochemical devices, super- capacitor in this paper, we basically focus on recent development of graphene-based metal oxide nanocomposite materials for energy related application.

Keywords: Graphene, Graphene oxide, Metal oxide nanocomposites, Energy, Water remediation.

I. Introduction

I.1. Nanocomposites

Nanocomposites are the materials which contain the mixtures of different phases in which at least one of its dimensions fall in nanosized dimensions ($1 \text{ nm} = 10^{-9} \text{ m}$).^{1,2} Nanocomposite materials have shown various applications in the field of electronics, atmosphere, packaging, automotive, biotechnology, sensors, energy, environmental remediation and many other applications. The nanocomposite has a nanoscale structure that increases the macroscopic properties of the materials as compared to single phase materials. Nanocomposites are different from other composite materials because of its special properties like remarkably high surface to volume ratio and high aspect ratio.²⁻⁶ Core-shell and coated nanomaterials are also examples of nanocomposites. In case of coated nanomaterials, nanoparticles are decorated on a supporting materials or matrix. These nanocomposites are high performance materials that show remarkable properties in combinations as compare to their single component counter parts.

I.2. Graphene: History and development

Single layered graphene was first introduced theoretically by a Canadian theoretical physicist Wallace in 1947. It was first prepared using a simple and cost-effective exfoliation method. After that, graphene was widely used in numerous tenders and became more popular among researchers in various fields. Due to its outstanding properties such as very high surface area ($2630 \text{ m}^2/\text{g}$), stability, unique electrical properties, it can be used in various research fields.⁷⁻⁹

However, direct application of graphene is limited for various fields despite its excellent chemical and physical properties. Again, the sheets

incline to form irreversible agglomerates in aqueous solution due to the Vander Waals interactions the graphene layers are not separated. These properties of graphene are not suitable for energy and environmental application. Therefore, researchers are grown different nanomaterials on graphene surface. For these properties graphene based materials can improved its performance and hence these materials are widely used in various application such as adsorption, photocatalytic degradation of different pollutants, memory devices, molecular imaging, biomedical science, and even drug delivery.^{6,10-13}

1.3. Graphene based metal oxide nanocomposites

Graphene has 2D network type structure and interesting properties. Therefore, recent researches focus on decoration of inorganic nanoparticles on graphene surface to improve their properties. These nanocomposites can refer new functionalized graphene materials aiming for energy and environmental application through the combine properties of individual components. Till date, a large number of metals (including Ag, Au, Cu, Rh, Fe and Co) and metal oxides (including Fe_2O_3 , Fe_3O_4 , FeOOH , Al_2O_3 , AlOOH , TiO_2 , MgO , MnO_2 , ZnO , SnO_2 , CuO and MFe_2O_4 (M=Zn, Mg, Mn)) nanostructures have been decorated with graphene and their derivatives like reduced graphene oxide (rGO) and graphene oxide (GO) and used for various application in different field.¹³ The mixture of graphene and metal oxide nanocomposite is not only extending the life time of the nanomaterial but also acting a better support material.

2. Graphene based metal oxide nanomaterials for energy applications.

Graphene based metal oxide nanocomposites have been extensively used in the energy-oriented applications. There modern materials mainly used in solar energy renovation and electrochemical devices. In this section, we briefly discussed about the recent work progress in the field of lithium battery, photovoltaic/photoelectrochemical devices, super capacitor, and fuel cell. Because of the rapid development, large quantities of publications in journals , so it is difficult to cover all those.¹⁴⁻¹⁷

2.1. Solar energy conversion

2.1.1. Photovoltaic devices

Graphene based nanocomposites have exceptional electronic and optical properties. These properties make them more attraction toward photovoltaic/photoelectrochemical devices. Even if pure graphene was firstly introduced for solar cells application, Nowadays, graphene-based nanocomposites have been much more popular in the field of photovoltaic/photoelectrochemical application due to combine attraction. In this section, we discussed about some recently published graphene based metal oxide nanocomposites for photovoltaic/photoelectrochemical application.¹⁸⁻²²

Tang et al., have reported the synthesis of graphene/TiO₂ and TiO₂ nanomaterials by using this method. Then, the obtained nanomaterials were used for photoelectrochemical application and from the results it is shown that, Graphene based nanomaterials showed higher conductivity (two times) and power conversion efficiency (five times) higher than pure TiO₂. The photovoltaic performance of graphene/TiO₂ showed higher current density.

Park et al., have reported the synthesis of graphene based ZnO nanomaterials for photovoltaic application. Fig. 1 shows the overall device structure and (b) the corresponding flat-band energy level diagram.

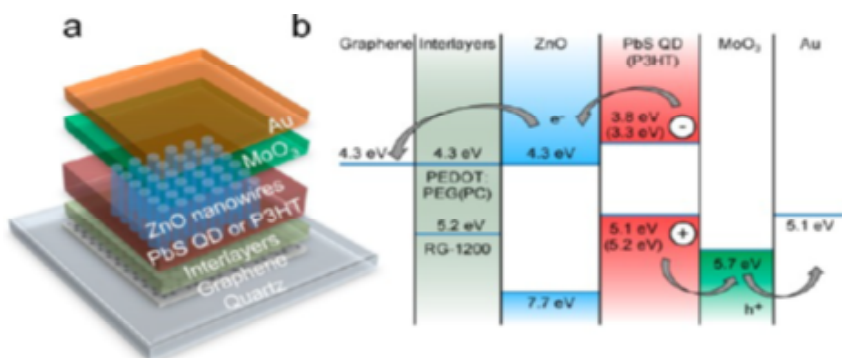


Fig. 1. (a) Overall device structure and (b) Corresponding flat-band energy level diagram.

The power exchange efficiencies are found to be 4.2%. Imamura et al., have also demonstrated the synthesis of graphene/SiO₂ nanocomposite for transistor application under ultraviolet radiations. From the obtained results, it was found that the inequity of graphene to UV light finds the graphene-SiO₂ interface. This indicates to increase the power of the devices. Again Ryuet al., are used graphene-NiO₂ nanocomposites as an anode. The solution of nickel oxide is prepared by sol-gel method. The efficiency of this material is found to be 3.48%.¹⁵⁻²²

2.1.2. Artificial photosynthesis

Graphene based metal oxide composites nanomaterials have much more attraction on artificial photosynthesis (i.e., water splitting through photochemical and photoelectron chemical way) due to their strong electron acceptor and charge transporter behaviors. Cost effective graphene-based mix metal oxides nanostructure can be much more potential as a co-catalyst like high-cost noble metal like Pd, Pt, Au and Ag. These metal co-catalysts are widely used in inorganic semiconductors-based photochemical water splitting. In graphene-based metal oxide nanocomposites, graphene works not only as co-catalysts but also conductive channels for nanomaterials in photoelectrochemical water splitting application. So recently, graphene-based nanomaterials are much more popular among all co-catalyst for water splitting application. Some of them are discussed below.¹⁰⁻²⁰

Among Various graphene-based metal oxide nanocomposites, TiO₂ decorated graphene are more popular in water splitting under sunlight due to its thermal and chemical stability, super hydrophilicity, less toxic, and natural geologic abundance. In these materials, graphene acts as co-catalysts to increase the charge separation under sunlight. Let al., reported the synthesis of graphene-TiO₂ nanocomposites using simple and cost-effective sol-gel method and used as photocatalysts for H₂ generation under solar light. They have also synthesized TiO₂ nanocomposite for comparison study with graphene-TiO₂ nanocomposite and it is shown that graphene-based nanomaterial was achieved 1.9-time higher H₂ production than pure TiO₂. In another study, Xiang et al., have used hydrothermal method for the fabrication

of same graphene-TiO₂ nanocomposites for H₂ generation. From the results, it is demonstrated that GO-TiO₂ showed higher efficiency for H₂ evolution than TiO₂/Pt nanocomposite. Again, Cu cluster-based graphene-TiO₂ was also used to increase the efficiency of hydrogen evolution of graphene-TiO₂ nanocomposite. Graphene/TiO₂/MoS₂ nanocomposite was also applied for H₂ production (Fig. 2). In this nanomaterial, graphene and MoS₂ pick up the photocatalytic performance due to the synergetic effect of graphene and MoS₂. This nanocomposite was produced huge amount of hydrogen with production rate of 165.3 μmol/h.¹⁵⁻²¹

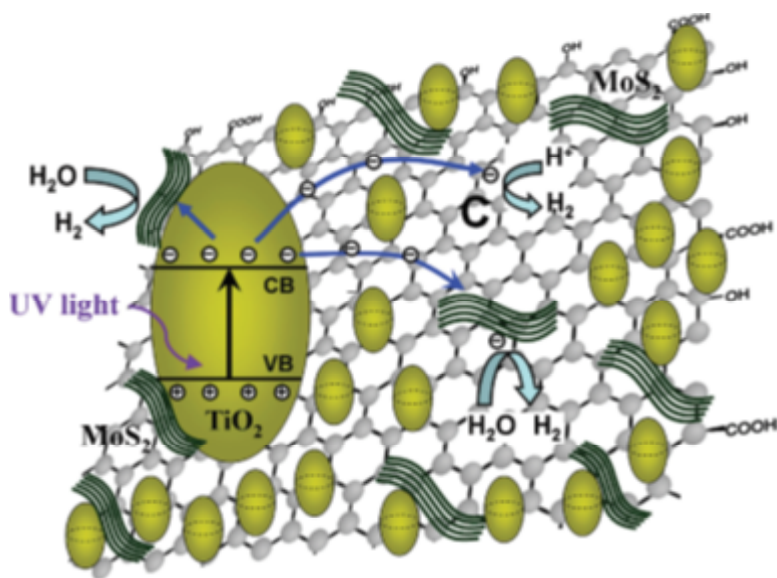


Fig. 2. Schematic illustration of the charge transfer in Graphene/TiO₂/MoS₂ composite.

Graphene based inorganic semiconductor materials are not only used for water splitting under sunlight irradiation but also applied in PEC water splitting. Recently, a number of graphene-based metal oxide nanocomposites are used for PEC solar water splitting for example

GO based BiVO_4 , Fe_2O_3 , Cu_2O and WO_3 . Ng et al., have prepared bismuth vanadate (BiVO_4)/reduced graphene oxide composite nanomaterials for increasing the visible light photo response in hydrogen production under water splitting (Fig. 3). The water splitting can be achieved maximum at the 0.8 V. Houet al., also prepared $\alpha\text{-Fe}_2\text{O}_3$ /graphene/ $\text{BiV}_{1-x}\text{Mo}_x\text{O}_4$ hetero-junction arrays and used for PEC water splitting to achieve a high photo conversion efficiency of 0.53% compared to other related composites.

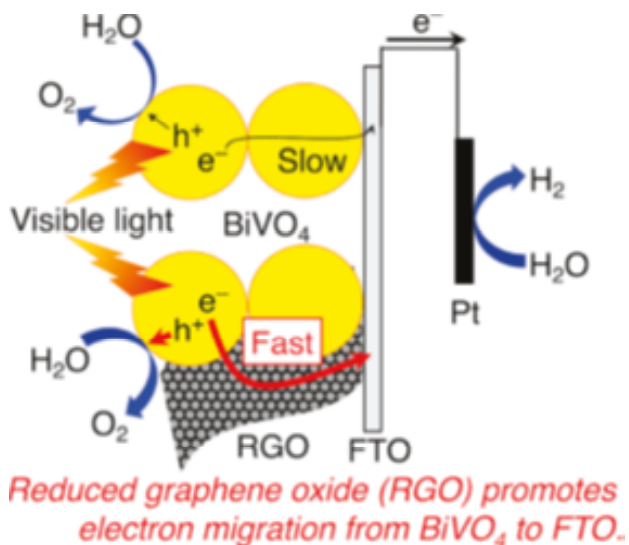


Fig. 3. Schematic illustration of the charge transfer and H_2 evolution in bismuth vanadate (BiVO_4)/reduced graphene oxide composite

2.2. Electrochemical energy devices

2.2.1. Lithium-ion battery and lithium battery

Recently, budding of high performance and rechargeable lithium-ion batteries anode (LIBE) materials are received great importance of electronics devices and all vehicles. Graphene gives an outstanding stage for LIBE materials because of its better conductivity compare to other

materials, very high surface area, and less weight. Graphene based metal oxide composite nanomaterials have huge potentials to increase the capacitance, cycling stability and rate recital in LIBE.^{22,23}

Very recent Yu et.al, have reported the synthesis of reduced graphene oxide (rGO) based TiO_2 -Ag nanocomposites using simple solvothermal method. Then the prepared nanocomposites are used for LIBE. From the experimental results, it is found that, this material shows a competitive reversible capacity of 196.9 mA/h get a current density of 1C after 100 cycles. rGO-ZnO SnO_2 ternary nanocomposites was developed by Kose et.al, for lithium-ion anodes.²⁴ The results demonstrated that ternary rGO-ZnO SnO_2 lithium-ion anode produced larger discharge capacity as well as retention capacity than the ZnO SnO_2 binary anodes even after hundred cycles.

Huang et al, also reported the synthesis of rGO decorated SnO_2 nanocomposites using hydrothermal method for lithium-ion anode application. The material shows better electrochemical properties and enhances the cycle performance rate compared to pure rGO as well as SnO_2 . This result is due to the synergistic effect between the rGO and SnO_2 . In energy storage applications, mixed transition metal oxides have received much more attention. Recently, Sanchez and co-worker have used graphene based porous Ni-Co-Mn ternary metal oxide nanocomposite for Li-ion batteries anode and exhibited a high capacity of 115 mAh/g at 1 A/g (Fig. 4).¹⁴

Wang et al, also developed a three-dimensional sandwich like graphene based hollow spheres MnCo_2O_4 nanocomposite and used as anode materials for high performance LIBE. These nanocomposites increase considerably the rate of capability that is 538/ mA/ h/g at a high current density of 1000/ mA/ /g with outstanding cycle performance that is 703/ mA/ h/g after 100 cycles at 200/ mA/g. Other graphene-based metal oxides are also used for LIBE application; some of them are listed in Table-I.

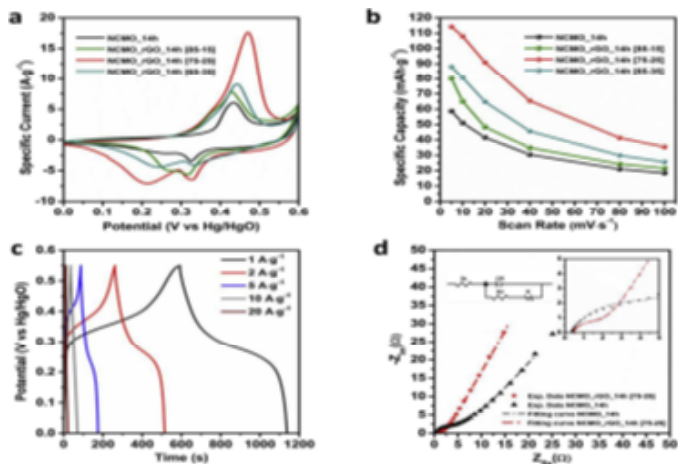


Fig. 4. Electrochemical evaluation as battery-type electrode materials in 3M KOH solution: (a) CV curves (b) Rate capability of the samples at various scan rates; (c) charge-discharge profiles; (d) Nyquist plots of the graphene-based Ni-Co-Mn metal oxide nanocomposite.¹⁴

Table I. Graphene based metal oxide nanocomposites for lithium-ion batteries electrodes.

Materials	Performance
Graphene-mesoporous SnO ₂ ²⁵	847.5 mAh/g
Graphene-MoO ₃ ²⁶	1225 mAh/g
Graphene-SnO ₂ - nitrogen doped ²⁷	1220 mAh/g
Graphene-Fe ₂ O ₃ ²⁸	910 mAh/g
Graphene Oxide- SnO ₂ Quantum Dots ²⁹	1121 mAh/g
Reduced Graphene Oxide- Hollow Nano-barrels Fe ₂ O ₃ ³⁰	1279 mAh/g
Graphene aerogel/Amorphous SnO ₂ ³¹	700.1 mAh/g
Graphene-Cobaltite oxide nanosheets ³²	4150 mAh/g
Reduced graphene oxide-spinel oxide ³³	700 mAh/g
Hierarchical Porous Graphene-CaO ³⁴	656 mAh/g
MOF-derived octahedral CuO wrapped 3D graphene network ³⁵	409 mAh/g
Highly Flexible Graphene/Mn ₃ O ₄ ³⁶	800 mAh/g
Graphene-Fe ₂ O ₃ ³⁷	1200 mAh/g

Conclusions

This working paper mainly focused on the energy applications of metal oxide nanomaterials functionalized graphene or its derivatives. From the above discussion we found that many progress have been made for the preparation and applications of graphene-based metal oxide nanocomposites and used for energy (lithium battery, photovoltaic/ photoelectrochemical devices, super capacitor) applications.

Acknowledgement

The authors thankful to NIT Rourkela, Odisha, India for funding

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Acid Soils and their Management: An Insight

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
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Abstract

Soil is the basis of life on earth. Physical as well as the chemical health of soil is important to sustain life on earth. Physical health includes the structure, texture and aggregates of the soil. The chemical health includes the pH, EC, nutrient contents etc. When the chemical composition of the soil gets disturbed, it lead to various problem soils. One among them is the acid soil. Soil acidity is the most common and most important soil problems. It becomes difficult to feed the whole population with the limited amount of soil, out of which most of the soil have become problematic. It has been found that out of the total land surface in Asia about 38% are acidic. Acid soils are highly infertile and are Al and Mn toxic. The top soil of the acid soils are susceptible to erosion. If these are not managed properly they are very prone to fertility degradation. It is very difficult to sustain the production in this soils for a small and poor farmer. But the methods like zero till, minimum tillage, integrated

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crop livestock husbandry, and other low cost methods are effective in combating this problem to some extent. There is also a need to find out other cost effective options, not only to manage acidity, but also to reduce the source of acidity. Our further research should focus on development of tolerant varieties, understanding the different nutrient cycles, deeper knowledge about crop residue management and development of practices to increase soil organic matter.

Key words: acidity, pH, Aluminium, Manganese, Problem Soil, Liming, Liming materials

Introduction

Soil acidity refers to the presence of higher amount of hydrogen ions at the exchange sites and in the soil solutions. The main characteristics are low pH and low base saturation. Approximately 60% of the total land on the earth are acidic in nature. Out of the total land area of India, about 100 Mha is acidic. State wise data shows that almost 99% of soil in Assam, 30% of area of Jammu and Kashmir 80% area of Odisha, 88% area in Kerala, 45% of land in Karnataka and 20% in Maharashtra are acidic in nature. Acid soils develop in regions where precipitation exceeds evapo-transpiration due to which leaching of bases occurs. India is an agrarian society where maximum population depends on agriculture. Also being the second most populated country in the world, the demand for food is ever increasing. To meet the high demands soil health and fertility needs to be maintained. Soil acidity being the important parameter of soil health needs to be taken care of, in order to make the production sustainable. Proper knowledge about soil acidity and its reclamation is only way to maximise agricultural productivity. Acidic soil have excess of Al, Fe and Mn, among which Al is harmful for the root growth. Root apex is directly affected by the toxic level of Al, which in turn leads to reduced water uptake and nutrient scarcity. This as a whole reduces the growth and yield of the crops.^{1,2} Combination of mineral toxicity (aluminium, and manganese) and mineral deficiencies (phosphorus, potassium, calcium, magnesium, zinc, boron, etc) decreases productivity and fertility of soil.³⁻⁵

The major reason of soil acidity in the agricultural fields is the application of huge amounts of nitrogen especially in the form of ammoniacal and urea fertilisers. These indirect form of nitrogen releases hydrogen ions while getting converted into direct forms i.e., nitrates. As hydrogen ions saturation increase, the negative logarithm of hydrogen ions which is also known as pH decreases. Thus acid soils have characteristic low pH. The major reasons for soil acidification as well as its intensification are Heavy rainfall, leaching down of bases, mineralization of soil organic matter, and inappropriate agriculture practices. .

I. Soil acidity and its classes

I.1 Soil Acidity

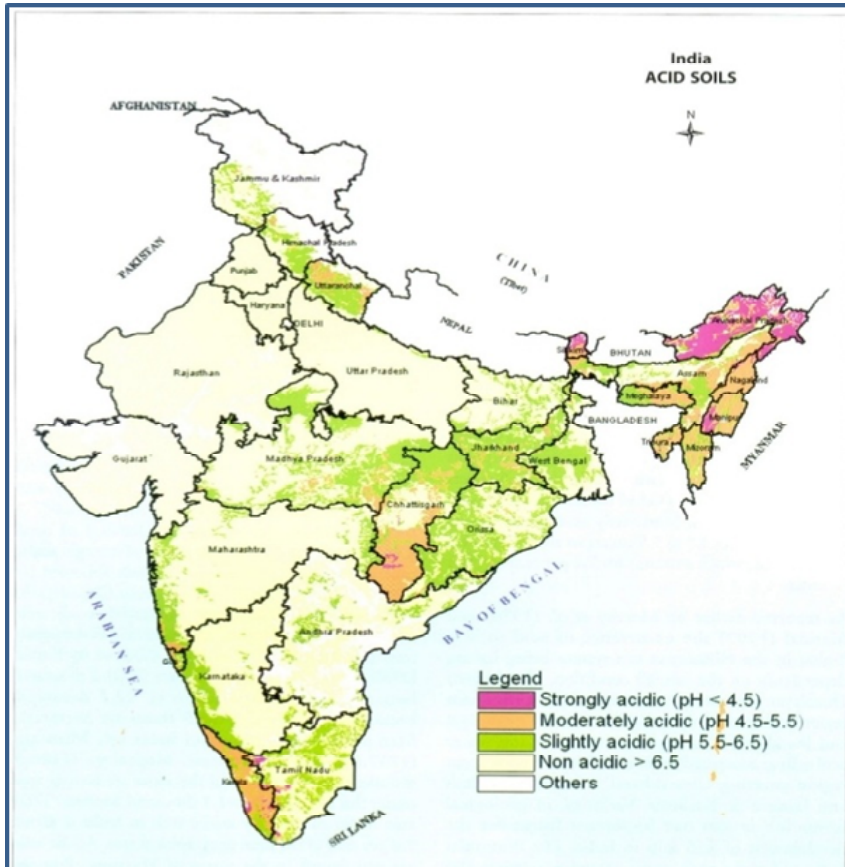
Soil is said to be acidic when the pH goes below 6.5. Acidic soils have been classified as given in the table I below.

Table I. Classification of Acidity

pH range	Nature of acidity
3-4	Very strong
4-5	Strong
5-6	Moderate
6-7	Slight

Occurrence of acidic soils are more frequent in Himalayan region. North eastern region and sub Himalayan region like Jharkhand and West Bengal has large areas under acid soil when compared to western Himalayan region like Uttarakhand, Himachal Pradesh and Jammu & Kashmir. In the Peninsular India, some of the coastal regions also shows acidic nature of soil.⁶ State wise soil acidity level has been depicted in the fig 1.⁷ The analysis of the following map depicts that 9.3% of the total geographical area of India is under highly acidic soil. And this 9% of the area spreads in the states like Arunachal Pradesh, Manipur, Sikkim, Tamil Nadu, Kerala, Chhattisgarh, Nagaland, Tripura and Assam. Chhattisgarh has the highest area under moderately acidic area followed by Kerala, Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya. This moderately acidic

soils comprises of 7.4% of the total geographical area. States like Haryana, Gujarat, Punjab, Rajasthan and Delhi are devoid of acidic soils.



1.1.2.1 Active Acidity

Active acidity is measured as the pH of the soil; it is the concentration of the hydrogen ion in the soil solution. This happens because the concentration of H^+ ions in soil solution is due to carbonic acid (H_2CO_3), water soluble organic acids and hydrolytic salts of the acid. It can be determined by measuring the pH of an aqueous suspension or a soil extract. It directly affects the growth of plants and microorganisms in the soil.⁹

1.1.2.2 Exchangeable Acidity

The colloids present in the soil adsorb some of the H and Al ions. There is a balance that exists between the ions that are adsorbed and the ions which are present in soil (i.e. active and exchange acidity). This equilibrium allows easy movement from one form to another. Exchange acidity is the hydrogen and aluminium, which can be easily exchanged in a simple saline solution such as KCl.⁸

1.1.2.3 Reserve Acidity

Concentration of hydrogen ions which are attached to the clay surface and the organic matter is known as Buffer pH. Reserve acidity is the amount of H and Al ions that can pass from the clay minerals to the soil solution. It is also known as potential acidity or adsorbed acidity.¹⁰ The relationship between the active and reserve acidity depends on the soil. The proportion of clay, organic matter and lime content determines the relationship. The ratio between active and reserve acidity is known as the buffer capacity of the soil. More is the clay content more will be the buffer capacity. Thus sandy soils will have lesser buffer capacity than the clayey soil. pH buffer of acid soil is measured to find out the lime requirement to neutralise some amount of reserve acidity also.¹¹

1.1.3. Sources of soil acidity

Acid forming process is a complex method. It is the sum total of natural and anthropogenic processes.

- Major source of acidity is the acidic parent material like granite, which during the process of soil formation contributes to the soil acidity.
- Heavy rainfall, leading to washing away and leaching of the bases.
- Acid forming Fertilisers which are used in the field especially those which contain organic and ammoniacal forms of nitrogen.
- Extreme weathering of rocks in the places with hot and humid climate and severe rainfall.
- Laterization, podzolization and accumulation of the undecomposed organic matter under marshy and swampy conditions renders soil acidity.

1.1.3.1 Leaching and Rainfall

Excessive precipitation is an effective agent for the long term removal of basic cations. With an increase in precipitation, the dissolved salt content drops to a low level and any calcium carbonate and gypsum present is removed. When a large amount of water drains quickly through the soil, runoff is most effective in making the soil acidic. Sandy soils often first become acidic due to the rapid infiltration of water, and sandy soils have only a small base reservoir (buffering capacity) due to their low clay and material content. organic.¹² Excessive precipitation leaches basic soil elements (Ca, Mg, Na and K) and increases soil acidity (Foy, 1984). Heavy rains leach out dissolved nutrients such as Ca and Mg which are specifically replaced from exchange sites by Al.⁸

1.1.3.2. Parent Material

Due to the different chemical composition of the base material, the soil becomes acidic after a different period of time. Granite rock soils show greater acidity than calcareous soils.¹³ When the alkali-deficient rocks disintegrate or decompose during the accumulation process, the soil material is acidic, even if there is no alkali loss during the soil formation process. Large areas are formed by acidic silica source rocks and sandy soils, which always require lime.¹⁴ However, most acid soils are formed because nutrients are leached and alkali is removed by the crops.⁸ Soils with a pH below 4 are very acidic, and most soils have a pH between 4.5 and 6.5. The country's high-altitude soils have the longest reaction time, low exchangeable cation content, and low alkali saturation.¹⁵

1.1.3.3. Decomposition of organic matter

Decomposition of organic material leads to release of carbon dioxide. This carbon dioxide reacts with water to produce weak acid known as Carbonic Acid. Similarly many other weak acids are formed due to decomposition of organic matter. Thus these weak acid accumulate to contribute to the soil acidity. Reactive groups like carboxylic, enolic and phenolic groups present in the humus also behaves as weak acid and contribute to soil acidity. Replacement of bases on exchange complexes with H⁺ ions leads to formation of organic acids and CO₂.¹¹

1.1.3.3. Application of acid forming Fertilisers

Ammoniacal forms of fertilisers leads to increase in soil acidity. Besides the ammonia based fertilisers, urea based fertilisers and organic fertilisers also contribute to soil acidity. As these sources are not direct sources of nutrients, these releases hydrogen ions in the process of getting transformed. Another reason for increased acidity due to nitrogenous fertiliser is the high yield which in turn removes basic cations from the soil.

1.1.3.4. Crop Removal

Due to the harvesting of high-yielding crops, the removal of elements is responsible for the acidity of the soil, especially the soil with a small reserve of alkali. Harvesting of high-yielding crops plays the most important role in increasing the acidity of the soil. To meet their nutritional needs, crops absorb basic elements such as Ca, Mg and K during the growth process. Compared to parts of plant leaves and roots, cereals produce less amount of these essential nutrients. Therefore, harvesting 4,444 types of high-yielding grasses, such as Bermuda grass and 4,444 alfalfa, has a greater impact on soil acidity than harvesting 4,444 types of grains.¹⁶ Changes in land use and management practices can improve the physical, chemical and biological properties of the soil.¹⁷ This practice resulted in an increase of in bulk density and a decrease in the content of soil organic matter (SOM) and CEC¹⁸, which in turn reduced the fertility status of certain types of soil.

1.2 Limitations of Acid Soil

1.2.1 Physical limitations in acid soils

- Washing of the bases, fine soil particles and organic substances
- Sandy soils have more porosity
- Fragile soil structure
- High rate of infiltration and permeability ,
- moisture holding capacity is less
- Formation of crust on soil surface, especially in red and laterite soils
- Increased susceptibility to soil moisture stress

1.2.2 Chemical limitations in acid soils

- P becomes less available and fixed
- Toxicity due to Al, Fe and Mn
- Low organic matter status of lateritic and red soils
- (Ca, Mg, Mo, B and Zn deficient
- Subject to greater leaching of nutrients
- Nutrient unbalance and low CEC and base saturation
- More presence of kaolinite and sesqui-oxides

1.3 Management of Acid Soils

1.3.1 Use of Liming materials

Liming is beneficial for acidity neutralization, microbial activity enhancement, improvement of physical properties and nutrients availability of the soil. All these cumulatively impact on crop productivity (Table 2).

Table 2. Average yield of wheat as affected by lime and fertilizer treatment at Palampur¹⁹

Dose of Lime (kg/ha)	Yield (kg/ha)			Mean yield (kg/ha)
	T1	T2	T3	
0	2247	4152	4726	3708
784	3525	4664	5464	4551
924	3214	4600	5691	4502
Mean	2295	4472	5294	4254

T1- Recommended dose of N, T2- Recommended dose of N and P, T3- Recommended dose of N, P, K

1.3.1 Agronomic Measures

1.3.2.1 Crop Scheduling

Under rainfed conditions (the effect of lime material application weakens rapidly), highly sensitive crops such as cotton, soybeans, pigeon peas, peanuts, green beans, etc., should be planted with lime in the first year.

. The next season should be moderate response crops such as corn and wheat. Less sensitive crops, such as millet, rice, barley, linseed, etc., should be planted in the year before the start of the next liming program.

1.3.2.2 Crop diversification

Location specific crop diversification with acid tolerant crops like tea, groundnut, maize etc. should be followed.

1.3.2.2 Suitable crop selection

The crop choice is an important matter for obtaining productivity in acid soils. Based on the extent of acidity fruit orchards are to be established considering the tolerance level of crops (Table 3).

Table 3: Relative tolerance of fruit crops to soil acidity

Slightly tolerant to acid soil (pH 6.8-6)	Mango, citrus, Banana, Guava, Papaya, Cashew, Carambola, Apple, Peach, Kiwi fruit
Moderately tolerant to acid soil (pH 6.8-5.5)	Pineapple, Orange, Litchi, Passion fruit, Jackfruit
Highly tolerant to acid soil (pH 6.8-5)	Elephant apple, Bel, Strawberry, Gooseberry, Plum

1.3.2.3 Integrated farming system

Livestock farming system will give the manures and these manures will be of multiple use for field application and biogas production. The biogas slurry obtained is an excellent source of organic manure.

1.3.3 Soil manipulations

- Application of compost, green manure, straw, and including pulses in crop rotation to increase the aggregate stability.
- Crust formation can be controlled by straw mulch on seed lines, incorporation of powdered groundnut shell, paddy husks two weeks before seeding.
- Addition of tank silt and clay to increase water retentivity.

- Improvement of the soil structure, increasing the hydraulic conductivity, moisture holding capacity, increase in the pore space, decreasing the bulk density can be done by application organic manure, crop residues etc.

1.3.4 Engineering Measures

- Converting the fields into Ridge and furrow, conservation tillage
- Contour cropping and strip cropping, bench terracing
- Making of field bunds for rain water harvesting
- Collection of runoff water and their recycling
- Soil compaction using heavy rollers and trolleys
- Disturbing the soil to a depth of 30-45cm of compact soil using a chisel

1.3.5 Nutrient Management

Application of organic and inorganic sources of nutrient along with lime is beneficial. The application of organic fertilizers combined with inorganic fertilizers and lime has proven to be an excellent way to improve the productivity and health of acid soils. Apply FYM @ 5t/ha plus 10% of the lime requirement and 50% of the recommended dosage of inorganic fertilizer to continuously increase wheat yield.²⁰

Table 4. Yield of wheat (kg/ha) under different treatments in acid red loam soils of Bihar (Average of 7 years)²⁰

Treatment	Wheat yield (kg/ha)
Control	561
N	439
NP	1807
NPK	1903
FYM	1248
FYM +P	1251
FYM +PK	1264
L +NPK	1978
L+ FYM +PK	1396

N: sole application of Nitrogen, NP: recommended dose of N&P, NPK: Recommended dose of NPK, FYM: Farm Yard Manure, FYM+P: recommended dose of Phosphorus along with FYM, FYM+PK: recommended dose of P, K along with FYM, L+NPK: recommended dose of NPK along with liming@24kg/ha, L+FYM+PK: recommended dose of NPK along with liming@24kg/ha and FYM

2. Conclusion

Several studies shows that lime is necessary, but must be supplemented with balanced plant nutrients to obtain sufficient crop yields in areas prone to acidity sustainable soil management practices and maintain soil quality is agriculture The central issue Soil acidity and related low nutrient utilization is one of the main limiting factors for crop production. In general, lime should be considered as a soil amendment, which can increase the pH of soil to a level suitable for maximum nutrient availability, plant growth and crop yield. Residual effects of organic sources on crop production and soil properties can last for several years Therefore, its profitability cannot be accurately estimated in the short term, while its impact is in the long term. The application of organic residues not only increased the nutrient content of the soil, but also improved its physical and biological properties.

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Ethylene and Gibberellic Acid for Improving Sugarcane Productivity and Quality

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
Odisha, India

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Abstract

Sugarcane is an important commercial crop of India. Low sugarcane productivity and juice quality is a matter of concern. Rising population and growing requirement of sugar needs high sugarcane productivity. Plant growth regulators have been found to improve productivity and juice quality. Ethephon (an ethylene generating compound) and gibberellic acid has been found to improve multiple growth parameters and crop performance of sugarcane. As these plant growth regulators can ameliorate multiple agro-physiological constraints, hence they may also be helpful in improving yield and juice quality. In the present article attempt has been made to review the importance of two plant growth regulators on productivity and juice quality of sugarcane.

Keywords: Gibberellic acid, Ethephon, Sugarcane, Juice quality

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I. Introduction

Sugarcane (*Saccharum officinarum* L.) is an important commercial crop of India. Sugarcane also has large industrial significance as it is the second largest agro-industry sector only next to cotton. Sugar industry plays a significant role in the economy of India, hence affects the socio-economic development of the country, especially in rural areas where livelihood is mostly agriculture dependent. In India around 6 million farmers are involved in the activity of sugarcane production. In addition to that, around 0.5 million workers, are also engaged in sugar production Industry.

By 2030, India is expected to 520 million tonnes of sugarcane with an average sugar recovery of 10.75 % This needs a quantum jump from the present level of sugarcane productivity and sugar recovery which stands at 348.04 million tones and 10.23% respectively. To achieve the abovesaid target by 2030, yield of 100-110 tonnes/ha (presently 70 t/ha) is required, considering the fact that area may stabilize around 5.00 mha. Looking at the yield and sugar recovery pattern of recent past, it can be said that the target is difficult to achieve (Economic survey 2013-14).

Many agronomic improvements have been done in terms of tillage, nutrient management, weed management, water management etc. However, there is further scope of improving yield especially by improving crop performance at physiological level. PGRs (plant growth regulators) have been found to alter and improve crop physiology when applied at right time and at right dose. However, understanding the role of a particular PGR is not very easy as most of the plant growth regulators have multiple roles. Moreover, the performance of growth regulators may vary from crop to crop. Hence experiments must be conducted to evaluate the performance of different plant growth regulators for different crops to know their possible beneficial effects on plant growth and development.

PGRs like ethephon (an ethylene generating compound) and gibberellic acid can positively improve cane productivity and sugar recovery in

sugarcane.¹⁻³ As plant growth regulator have been known to ameliorate various agro-physiological constraints, hence plant growth regulators (PGRs) can be used to improve the productivity and juice quality of sugarcane. In the following sections attempts have been made to review the available literature on two plant growth regulators.

2. Ethephon (2-chloroethylphosphonic acid)

Plant growth regulators have great potential to ameliorate multiple physiological constraints and hence, can improve crop performance. Ethephon (ethephon, 2-chloroethyl phosphonic acid), is an ethylene generating compound. Ethephon is an efficient growth regulator, which when metabolized in plants, animals and soils via hydrolysis, produces HCl, H₃PO₄ and ethylene gas and the resultant products are non-toxic and are found in all plants naturally. Ethylene can alter development of higher plants in multiple ways, like controlling germination time, leaf expansion, abscission, ripening of fruits and stress-responses in plants.⁴ ⁶ The potential of ethephon in improving sprouting of setts has been demonstrated in multiple countries.¹ Improvement in sett sprouting and settling vigour was observed when ethephon treated seed cane pieces were planted.² It has been found that root length, root number and root fresh weight improves due to ethephon treatment.¹ Setts treated with ethephon, showed higher shoot height, shoot fresh weight and leaf area. Sprouting improvement by ethephon treatment showed a corresponding increase in acid invertase activity and reducing sugars in the sprouted buds. Earlier research conducted in sub-tropical India using ethephon also showed encouraging results on the sett and underground buds sprouting.^{7,8}

Ethephon, when applied to the crop foliage at pre-harvest stage increased reducing sugars in the sprouted buds of sugarcane ratoon.⁹ Extensive work has been done by Jain *et al.* (2011) on biochemical attributes of ethephon treated setts.¹ They found an improvement in reducing sugars, activity of acid invertase and ATPase activity in all the three treatments (preharvest ethephon soaked setts, setts soaked in Ethephon solution and furrow applied Ethephon over the setts at planting) over control. The reason for higher sprouting can be explained based on the findings

of Jain *et al.* (2007).¹⁰ They explained that acid invertase hydrolyses sucrose into hexoses and ATPase liberated inorganic phosphorus. This process provided cells with carbon and energy for multiple compound synthesis, which are essential for sprouting. Diaz *et al.* (1995) reported from Cuba that ethephon applied at 120, 240, 360 and 480 ppm for three minutes significantly improved germination of four sugarcane varieties. In addition, significant increase in stalk population and cane sugar yields of two poor germinating varieties were observed when setts were dipped in 120 ppm ethephon solution before planting.¹¹

Gayler and Glasziou (1972) showed a strong relationship between elongation of immature internodal tissues of sugarcane and total invertase activity.¹² Treatment with ethrel releases ethylene in tissues that stimulates peroxidase activity that leads to the destruction of endogenous auxins, which results in bud's inhibition.¹³ It has also been reported that higher concentration of auxin, when exogenously applied induce the synthesis of ethylene in the treated tissues, which results in the loss of apical dominance and thus improves sprouting.¹⁴

Wen *et al.* (1989) from south China showed that, seed cane pieces when soaked with 50 ppm, 100 ppm and 200 ppm ethephon solutions, improved germination, tillering and early growth of sugarcane, however higher concentrations showed inhibitory effect.¹⁵ It has also been found that ethephon treated at early stage (at low concentration) or soaking seed canes also improved the drought resistance ability.²

3. Gibberellic acid

Gibberellins (GAs), are a group of tetracyclic diterpenes, has significant effect on multiple plant development activity.¹⁶ They are also known to improve plant physiological activity. Gibberellic acid (GA₃) can also enhance the source potential and sink strength.¹⁷ Several factors either environmental conditions or endogenous has impact on sink strength, however the sink activity can be improved by Gibberellins.¹⁸

In addition to the roles of gibberellic acid in non-stressed environment, GA plays an equally important role in improving source–sink relationship in stresses environment. Exogenous application of

Gibberellic acid can ameliorate the abiotic stress impact to some extent. Under stressed condition, photosynthetic potential and sink strength is improved.¹⁹ First attempts to use gibberellic acid for increasing sugarcane yields were reported in 1956 by Anon. Since then, a number of papers have reported the effects of gibberellic acid on sugarcane and the potential of this hormone for increasing sugar yields. In 1956, Anon reported that a series of 4 applications of GA₃ caused a 50% increase in stalk fresh weight and a 300% increase in gram pol in young sugarcane stalks.²⁰

Many field studies conducted to evaluate the effects of GA₃ on sugarcane yields, failed to show the expected yield increase.^{21,22} Villareal and Santos (1958) tried to evaluate the response of sugarcane to different rates of foliar application of gibberellic acid. They found that gibberellic acid hastened growth, but they were not able to note any improvement in tonnage and sugar yield. This result was attributed to insufficiency of needed nutrients to sustain growth and deposition of sugar. However, Coleman (1958) found that sugarcane was most responsive to GA₃ when plants were grown under cool weather stress conditions. It appears that gibberellic acid as a growth regulator exerts its beneficial effect when growth conditions are not favorable. Findings in Hawaii showed that gibberellic acids have more pronounced effect on growth when applied at low radiation months or short day²³ and during months with cool temperature.²¹

To understand the reasons for variable responses in sugarcane Bull (1964) conducted Growth chamber experiments to quantify the effects of variety, plant age and temperature. The magnitude of the gibberellic acid responses was found to be a function of each variable. It was found that younger plants at lower temperature showed greatest responses.

Increase in internode length is the most characteristic response to exogenously applied gibberellins. As sugarcane also responds to Gibberellins in a similar, an increase in shoot length will provide an opportunity to increase sugarcane yield.^{24,25} Sugar transformation occurs in storage tissue in response to foliarly applied gibberellic acid. Hence,

given proper condition for tissue penetration, gibberellic acid can increase juice quality and productivity.²⁶

In an experiment, six sugarcane varieties were subjected to foliar spray of gibberellic acid. It was found that split application of gibberellic acid at different concentrations did not significantly improve growth and different yield components of sugarcane. Rather, responses obtained were only due to varietal difference. Several possible reasons could be forwarded to explain the inefficiency of foliar application of gibberellic acid to appreciably promote growth of sugarcane in this study. First, the level of endogenous gibberellic acid in the plant system might be adequate enough for vegetative growth since the test plants were not dwarf varieties. Second, the test plants suffered adverse mechanical damage due to lodging. This in turn renders the sugar making capacity of the leaves quite inefficient due to overcrowding and mutual shading. Moreover, lodging stimulated sucker formation which competes for stored sugar in matured stalk.²⁷

Gibberellic acid improves sucrose synthesis through their positive effects on sucrose phosphate synthase and fructose-1,6-biphosphatase. Gibberellic acid can also stimulate phloem loading and mediate assimilate translocation.²⁸ Gibberellic acid treatment improves sugar and fibre contents, decreased leaf weight and leaf area, but had no effect on node number. The magnitude of the response differed with variety and temperature. The response of gibberellic acid is greater in sugarcane grown under cool temperature than in sugarcane grown under warmer temperature.²⁴

Varma *et al.* (1963) found that of 100ppm gibberellic acid, when applied foliarly, improved juice quality of sugarcane.²⁹ Devi *et al.* (2011) found no significant difference in cane yield due to sett treatment with carbendazim @ 0.1% + gibberellic @ 100ppm for 15minutes.³⁰ She found no significant improvement in sucrose content in juice. Mohanty *et al.* (2011) found that treatment of sugarcane setts with carbendazim and 100 ppm solution of gibberellic acid improved germination percentage significantly which was 16% higher over control.³¹ GA application was done in sugarcane variety CoSe 92423. GA treatment,

showed 10-times higher extension rate along with higher partitioning of dry matter in to the stalk. Higher activities of nitrate reductase, acid invertase, protease enzymes, amylase and concentration of soluble carbohydrate in leaf tissues of gibberellic acid treated plants (IISR Annual report 2009-10).

El-lattief and Bekheet (2012) conducted a field experiment at Egypt to see the effect of different growth regulators on quantitative and qualitative characters of three sugarcane varieties.³² The study indicated that foliar spray of GA₃ at concentration of 300 ppm improved the growth and quality parameters of sugarcane. Sugar yield was also positively correlated with stalk height, stalk thickness, number of valid stalks, cane yield, brix value and pol %.

4. Conclusion

Sugarcane in India have low productivity and juice recovery, which need further improvement to meet the future demand. However, the land and resource base will remain either constant or may decrease further. Use of plant growth regulators such as gibberellic acid and ethephon has the potential in improving crop growth, productivity and juice quality in sugarcane, when applied at right stage and right amount. The resulting response of growth regulators may vary depending on crop variety, climate and season. Hence, location and variety specific performance may be studied before recommending a growth regulator.

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Selection of Suitable Solvents in NMR Analysis

Centurion Journal of
Multidisciplinary Research
ISSN: 2395 6216 (PRINT VERSION)
ISSN: 2395 6224 (ONLINE VERSION)
Centurion University of Technology
and Management
At - Ramchandrapur
P.O. - Jatni, Bhubaneswar
Dist: Khurda – 752050
Odisha, India

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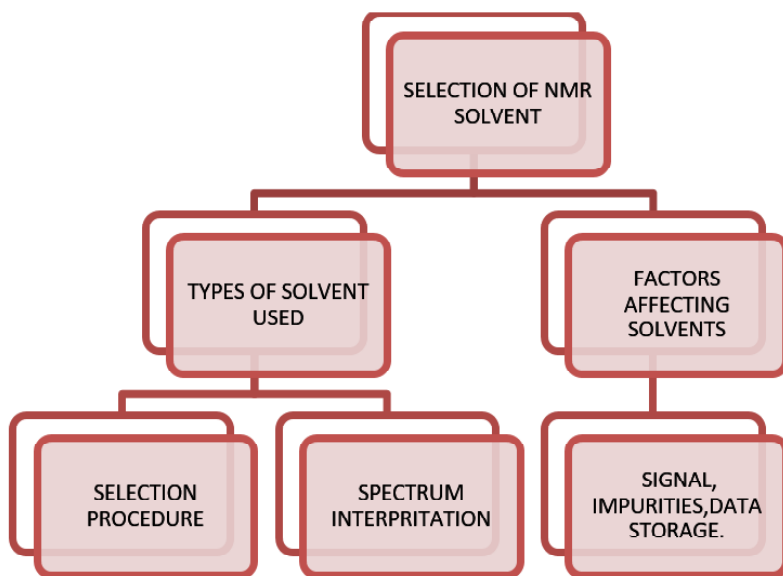
Abstract

This paper is developed in review of NMR solvent selection. In order to select solvent for NMR, we need to focus on some basic but major components which we will discuss further. This project mainly involves the characteristics; selection procedure and effect of NMR solvent. There are different ways of identifying the unknown structure of the chemical compounds like NMR, IR, MASS, XRC. But here we will discuss about the unknown structure of any organic or inorganic compound by using NMR. Fundamentally, this project emphasis on some basic characteristics of solvents which are required to be complied by the solvents to reach the criteria of being an ideal solvent of NMR. Here we will discuss about list of NMR solvents mostly used in NMR spectroscopy. By the end of this project, along with characteristics, we

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will also grasp some knowledge regarding impurities, peaks, signals, storage, as well. Some figures and data charts are also given below for the better understanding.

Graphical abstract



Keywords:

NMR solvents, signal, data chart, impurities, storage

I. Introduction:

We are living in a surrounding where everything around us is made up of matter, and all matters are made up of atoms. When atom connects with each other they form molecules. Though understanding these matters, atoms, and molecules are tough enough it is also necessary in accordance to understand the physical world. Along with the terminology understanding the behavior is the key component to access the physical world more significantly. For the better understanding, in

1945 two American scientist, Felix Bloch and Edward Mills Purcell introduced the term NMR i.e., nuclear magnetic resonance. By using this technology scientists were able to observe the molecules more significantly in details. NMR spectroscopy is an analytical chemistry technique. It is the most powerful tool available for the determination of organic structure. To determine the structure, we have to prepare the sample. We have to add the suitable test with the soluble solvent to make the solution, which will be placed in the instrument to measure the spectra of the compound, where we can estimate the protons present in the NMR spectroscopy and we can estimate the carbons by using carbon NMR spectroscopy¹⁻⁷.

So, whatever may be the spectroscopy whether proton NMR or carbon NMR, the important thing is to prepare the sample where the selection of the solvent is an important task. As we know that NMR spectroscopy is the nuclei having $I=1/2$, if we choose the solvent having any nuclei with $I=1/2$ it can interfere with the study. ^1H , ^{13}C , ^{19}F , ^{31}P have $I=1/2$. So, they are NMR active and can produce their own NMR signal. Generally, we can really absorb solvents with phosphorous and fluorine but many of the solvents are commonly have carbon and hydrogen. ^1H is simply called as proton. Proton is present in many of the solvents. So, if the proton is present it can interfere with the study. So, we have to select solvents which have no proton⁷⁻⁹.

Like in carbon tetrachloride, carbon has $I=0$ and Cl has $I=3/2$, so the both nuclei can't give NMR signal and therefore can't interfere with the study. That's why it can be used as a solvent. It is a non-polar solvent. It can solubilize only nonpolar compound. So, for polar compounds we have to select a polar solvent which don't have any proton. The most easily available and inexpensive solvent is water. But water having two protons having I value $1/2$, they will give own NMR signal. So, water can't be used as a solvent in NMR spectroscopy. So, we have to select a polar solvent which do not have any proton. If we remove the proton with ^2H (deuterium) having I value 1 , it can't give NMR signal and hence doesn't interfere with our study. In all the solvents the proton can be replaced by the deuterium, so that we can use the Deuterated solvent in the spectroscopy.⁴⁻¹⁰

2. Characteristics of solvent in NMR

It is very easier to select any solvent randomly, but there are some characteristics which are required to be fulfilled by the solvents to prevent further interruption. That's why some characteristics must be checked before considering it as an NMR solvent ¹¹⁻²⁰. Following are some characteristics discussed below-

- **SOLUBILITY**

Higher solubility of solvent gives higher sensitivity.

- **PURITY**

When it comes to characteristics of NMR solvents purity plays a very pivotal role. Presence of chemical impurities and water content may lead to interference in signal by giving peaks at higher chemical shifts.

Therefore, sealed glass bottles are used for storing high purity solvents. To prevent moisture intake or other impurities from the environment the bottle should be immediately closed after use. Little moisture can include water's protons into the solvent. We have to run solvent blanks in advance to confirm that the NMR solvent peaks don't interfere with the sample peaks further.

- **SOLVENT VISCOSITY**

Due to homogenization of the sample, lower viscosity will provide better spectral resolution.

- **MOISTURE CONTENT**

As we have discussed previously that water contains two protons itself, the presence of traces of water will lead to spectral interference. This will cause degradation in the quality of NMR spectra. But we cannot also deny the fact that all solvents contain some water.

In order to get rid of this problem, we need to seal the bottle of the solvent properly. Since, if the water content has already developed in the bottle, we need to reduce it by filtration through a drying agent.

- PRICE

Price is a matter of concern always. Here also we have to be concerned about the price while choosing large number of samples. The solvent price should be budget friendly. As the degree of deuteration increases the price also goes up. So, we must focus for solvents that perform well and do not prove to be heavy on the budgets.

- DEUTERATED SOLVENTS

As the majority of hydrogen nuclei are replaced with deuterium, NMR solvents are distinctly different from other spectroscopic solvents.

Besides all the characteristics discussed earlier, here are some other important characteristics given below-

- It should be chemically inert.
- It should be magnetically isotropic. If we are measuring from any direction in magnetic field, it will give the same result.
- It should dissolve the sample to a reasonable quantity.
- It should be devoid of H atom.
- It should be free from any hydrogen atom. According to this characteristic any hydrogen which contains 1H should be absent, because solvent will give the NMR peak. It is the reason behind using deuterium in proton NMR.

By keeping all the above factors in mind, we can easily pick a suitable NMR solvent.¹⁰⁻²³

2.1. Solvents used in NMR:

A solvent free of proton should be used i.e., which does not give absorption of its own in the NMR spectrum. The solvents should be capable of dissolving at least 10% of the substances under investigation. For dissolving polar compound, we will use polar solvent and for nonpolar compound we will use non polar solvent.

❖ Polar solvents- These are the solvents which have large dipole moment. Here the bonded compounds have measurable difference in electro negativity due to which they have large dipole moment. They contain bonds between atoms with different electro negativities.

e.g. - H_2O , NH_3 , SO_2 , H_2S , $\text{C}_2\text{H}_6\text{O}$.

❖ Non polar solvents- They are the solvents which contains bond between atoms with similar electro negativities. When the electro negativities of a bonded compound are similar at that time there is no dipole moment in the compound. There are two types of non-polar solvents i.e. Protic and aprotic.

e.g. - CO_2 , C_6H_6 , Cl_2 , O_2

Following are some commonly used solvents in NMR spectroscopy-

- | | |
|--|-----------------------------|
| i. Carbon tetrachloride (CCl_4) | viii. |
| Methylenechloride- d_2 | |
| ii. Carbon disulphide (CS_2) | ix. THF- |
| d_8 | |
| iii. Deutereo chloroform (CDCl_3) | x. Acetic acid- |
| d_4 | |
| iv. Hexachloro acetone (Cl_3) $_2\text{CO}$ | xi. Acetone - d_6 |
| v. Deuterated water (D_2O) | xii. Cd_3CN |
| vi. Methanol- d_4 | |
| vii. Pyridine- d_5 | |

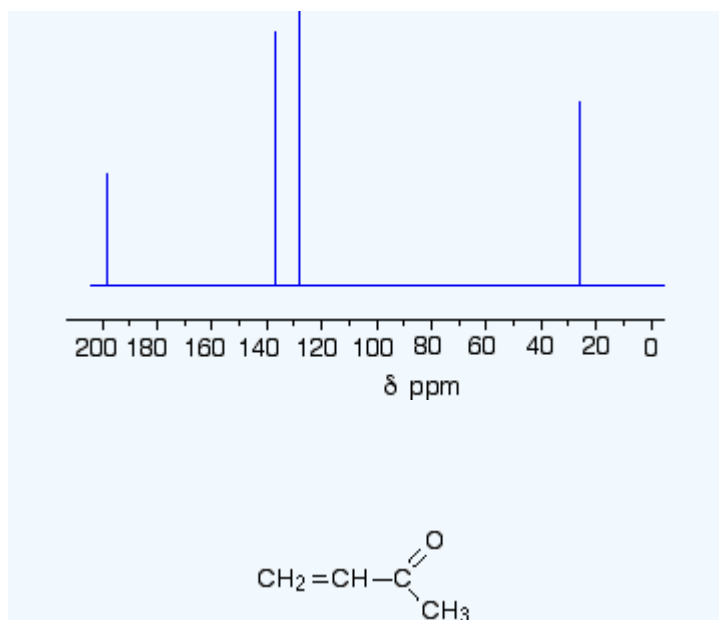
These solvents considerably differ from one another according to their polarity. NMR spectrum of a compound measured in one solvent may differ insignificantly. The very common and useful solvent used in NMR is Trifluoroacetic acid, whose proton absorbs at a very low field. It is useful for the NMR spectrum of amines. Dimethyl sulphoxide (DMSO) can be used in NMR spectroscopy.

Example-

(^{13}C NMR spectrum of but-3-en-2-one)

This is also known as 3-buten-2-one.

Due to the carbons at either end of the carbon-carbon double bond we got two peaks, one at 137 and another at 129 ppm. We get another peak at 200 ppm due to a carbon-oxygen double bond. The peak at 26 is the methyl group which is joined at the rest of the molecule by a carbon-carbon single bond.



(Figure-1: ^{13}C NMR spectrum of but-3-en-2-one)

The carbon-oxygen double bond in the peak for the ketone group has a slightly lower value than the ketone. The interaction between the carbon-oxygen and carbon-carbon double bonds in the molecules affect the value slightly. We get two peaks for the carbons in the carbon-

carbon double bond exactly at the expected place. They don't have the same shifts values as they are not exactly in the same environment. The methyl group on the end has exactly the sort of value we could expect for one attached to C=O and the one closer to carbon-oxygen double bond has the larger value. The table gives a range of 20-30. As in the molecule there are four carbons at four different environments, there are four peaks. But all the peaks are of different heights.

2.2. FACTORS AFFECTING NMR:

- Hydrogen bonding will increase the chemical shift as it causes deshielding of proton.
- It affects the delta value. Delta value will be increase or deshielding occurs generally if electronegative compounds will be present in the compound.
- Higher number of OH and NH group will lead to hydrogen bonding and ultimately deshielding take place. As high concentration of NH, OH present then electron cloud transfer takes place from hydrogen to electronegative compounds and ultimately hydrogen bonding takes place and delta value will be increased.
- According to this, deshielding occurs in hydrogen atoms.
- That's why delta value can be differ for same sample for different solvents.
- Chemical shift value may be differ for some molecule in different solvent.
- By decreasing the temperature hydrogen bonding can be decreased.

2.3. Chemical impurities table (using NMR):

These tables given below are in support of identification and separation of NMR signals of impurities that might originate from remaining solvents or from the extraction apparatus. Here we have

explained the NMR shift of the most commonly used solvents and impurities in organic synthesis measures in the spectrometer.¹⁵⁻²²

The given tables represent average values. The given values in the tables are temperature and partly concentration dependent. The ¹H-NMR data were obtained using a 300MHz and ¹³C-NMR data were obtained using a 75MHz.

¹H NMR chemical impurity shifts table-

	proton	mult	CDCl ₂	(CD ₃) ₂ CO	(CD ₃) ₂ SO	C ₆ D ₆	CD ₃ CN	CD ₃ OD	D ₂ O
Solvent residual peak			7.26	2.05	2.50	7.16	1.94	3.31	4.79
H ₂ O		s	1.56	2.84	3.33	0.40	2.13	4.87	
Acetic acid	CH ₃	s	2.10	1.96	1.91	1.55	1.96	1.99	2.08
Acetone	CH ₃	s	2.17	2.09	2.09	1.55	2.08	2.15	2.22
Acetonitrile	CH ₃	s	2.10	2.05	2.07	1.55	1.96	2.03	2.06
Benzene	CH	s	7.36	7.36	7.37	7.15	7.37	7.33	
Tert-butyl alcohol	CH ₃	s		1.18	1.11	1.05	1.16		
	OH	s	1.28		4.19	1.55	2.18	1.40	1.24
Tert-butyl methyl ether	OCH ₃	s	1.19	1.13	1.11	1.07	1.14	1.15	1.21
	CH ₃	s	3.22	3.13	3.08	3.04	3.13	3.20	3.22
BHT*	ArH	s	6.98	6.96	6.87	7.05	6.97	6.92	
	OH	s	5.01		6.65	4.79	5.20		
	ArCH ₃	s	2.27	2.22	2.18	2.24	2.22	2.21	
	ArC(CH ₃) ₂	s	1.43	1.41	1.36	1.38	1.39	1.40	
Chloroform	CH	s	7.26	8.02	8.32	6.15	7.58	7.90	
Cyclohexane	CH ₂	s	1.43	1.43	1.40	1.40	1.44	1.45	
1,2-dichloroethane	CH ₂	s	3.73	3.87	3.90	2.90	3.81	3.78	
Dichloromethane	CH ₂	s	5.30	5.63	5.76	4.27	5.44	5.49	

(Figure-2: chemical impurity shifts table of ¹H NMR)

¹³C NMR chemical impurity shift table-

2.3. Data chart of NMR solvent:

The H spectra of the residual protons and ¹³C spectra were acquired on a Varian Gemii 200 spectrometer at 295k. The NMR solvents used to acquire these spectra suppress a maximum of 0.05% and 0.01 TMS.¹⁻⁹ Since deuterium has a spin of 1 triplet, deuterium has the intensity ratio 1:1:1. Chemical shifts are solvent, concentration and temperature dependent. Every so often estimate values may differ with temperature, concentration and pH only.

	carbon	CDCl ₃	(CD ₃) ₂ CO	(CD ₃) ₂ SO	C ₆ D ₆	CD ₃ CN	CD ₃ OD	D ₂ O
Solvent signals		77.16	± 0.06	29.84 ± 0.01 206.26 ± 0.13	39.52 ± 0.06	128.06 ± 0.02	1.32 ± 0.02 118.26 ± 0.02	49.00 ± 0.01
Acetic acid	CO CH ₃	175.99 20.81	172.31 20.51	171.93 20.95	175.82 20.37	173.21 20.73	175.11 20.56	177.21 21.03
Acetone	CO CH ₃	207.07 30.92	205.87 30.60	206.31 30.56	204.43 30.14	207.43 30.91	209.67 30.67	215.94 30.89
Acetonitrile	CN CH ₃	116.43 1.89	117.60 1.12	117.91 1.03	116.02 0.20	118.26 1.79	118.06 0.85	119.68 1.47
Benzene	CH	128.37	129.15	128.30	128.62	129.32	129.34	
Tert-butyl alcohol	C CH ₃	69.15 31.25	68.13 30.72	66.88 30.38	68.19 30.47	68.74 30.68	69.40 30.91	70.36 30.29
Tert-butyl methyl ether	CCH ₃ C CCH ₃	49.45 72.87 26.99	49.35 72.81 27.24	48.70 72.04 26.79	49.19 72.40 27.09	49.52 73.17 27.28	49.66 74.32 27.22	49.37 75.62 26.60
BHT	C(1) C(2) CH(3) C(4) CH ₂ Ar CH ₂ C C	151.55 135.87 125.55 128.27 21.20 30.33 34.25	152.51 138.19 129.05 126.03 21.31 31.61 35.00	151.47 139.12 127.97 124.85 20.97 31.25 34.33	152.05 136.08 128.52 125.83 21.40 31.34 34.35	152.42 138.13 129.61 126.38 21.23 31.50 35.05	152.85 139.09 129.49 126.11 21.38 31.15 35.36	
Chloroform	CH	77.36	79.19	79.16	77.79	79.17	79.44	
Cyclohexane	CH ₂	26.94	27.51	26.33	27.23	27.63	27.96	
1,2-dichloroethane	CH ₂	43.50	45.25	45.02	43.59	45.54	45.11	
Dichloromethane	CH ₂	53.52	54.95	54.84	53.46	55.32	54.78	
Diethyl ether	CH ₃ CH ₂	15.20 65.91	15.78 66.12	15.12 62.05	15.46 65.94	15.63 66.32	15.46 66.88	14.77 66.42

(Figure-3: chemical impurity shifts table of ¹³C NMR)

	¹ H Chemical Shift (ppm from TMS) (multiplicity)	JHD (Hz)	¹³ C Chemical Shift (ppm from TMS) (multiplicity)	JCD (Hz)	¹ H Chemical Shift of HOD (ppm from TMS)	Density at 20°C	Melting point (°C)	Boiling point (°C)	Dielectric Constant	Molecular Weight
Acetic Acid-d ₄	11.65 (1) 2.04 (5)	2.2	178.99 (1) 20.0 (7)	20	11.5	1.12	16.7	118	6.1	64.08
Acetone-d ₆	2.05 (5)	2.2	206.68 (1) 29.92 (7)	0.9 19.4	2.8 *	0.87	-94	56.5	20.7	64.12
Acetonitrile-d ₃	1.94 (5)	2.5	118.69 (1) 1.39 (7)	21	2.1 *	0.84	-45	81.6	37.5	44.07
Benzene-d ₆	7.16 (1)		128.39 (3)	24.3	0.4	0.95	5.5	80.1	2.3	84.15
Chloroform-d	7.24 (1)		77.23 (3)	32.0	1.5 *	1.50	-63.5	61-62	4.8	120.38
Cyclohexane-d ₁₂	1.38 (1)		26.43 (5)	19	0.8	0.89	6.47	80.7	2.0	96.24
Deuterium Oxide	4.80 (DSS) 4.81 (TSP)		NA	NA	4.8	1.11	3.81	101.42	78.5	20.03
N, N-Dimethyl-formamide-d ₂	8.03 (1) 2.92 (5) 2.75 (5)	1.9	163.15 (3) 34.89 (7) 29.76 (7)	29.4 21.0 21.1	3.5	1.03	-61	153	36.7	80.14
Dimethyl Sulfoxide-d ₆	2.50 (5)	1.9	39.51 (7)	21.0	3.3 *	1.19	18.55	189	46.7	84.17
1,4-Dioxane-d ₄	3.53 (m) 5.19 (1) 3.56 (1) 1.11 (m)		66.66 (5) 17.31 (7)	21.9 19	2.4 5.3	1.13 0.89	11.8 -114.1	101.1 78.5	2.2 24.5	96.16 52.11
Ethanol-d ₄	4.78 (1) 3.31 (5)	1.7	49.15 (7)	21.4	4.9	0.89	-97.8	64.7	32.7	36.07
Methylene Chloride-d ₂	5.32 (3)	1.1	54.00 (5)	27.2	1.5	1.35	-95	39.75	8.9	86.95

(Figure -4: NMR solvent data chart)

2.4. Storage and handling information of NMR solvent:

- ❖ Deuterium oxide, Dimethyl sulphoxide $-d_6$, methyl chloride- d_2 , Trifluoroacetic acid- d , Acetic acid $-d_4$, Acetone $-d_6$, Benzene- d_6 , Cyclohexane $-d_{12}$, Ethanol $-d_6$, are such solvents which are store at room temperature. They are stable under recommended conditions.
- ❖ Away from light and moisture Acetonitrile- d is the solvent which is store at room temperature. This product will remain stable for one year after receipt of order if we store it under above condition. If we use the solvent after one year, it needs to be re-analyzed in purpose of checking chemical purity before use.
- ❖ Away from light and moisture Chloroform- d , Tetrahydrofuran- d_8 are store in refrigerated. These products remain stable for 6 months after receipt of order. After 6 months they should be re-analyzed before use.

2.5. NMR solvents signals

The chemical shifts (δ) of solvents signals observed for 1H NMR and ^{13}C NMR spectra are listed in the table given below. The multiplicity is shown in parentheses as 1 for singlet, 2 for doublet, 3 for triplet etc.

The chemical shifts (δ) of solvent signals observed for 1H NMR and ^{13}C NMR spectra are listed in the following table. The multiplicity is shown in parentheses as 1 for singlet, 2 for doublet, 3 for triplet, etc.

Solvent	1H NMR Chemical Shift	^{13}C NMR Chemical Shift
Acetic Acid	11.65 (1), 2.04 (5)	179.0 (1), 20.0 (7)
Acetone	2.05 (5)	206.7 (13), 29.9 (7)
Acetonitrile	1.94 (5)	118.7 (1), 1.39 (7)
Benzene	7.16 (1)	128.4 (3)
Chloroform	7.26 (1)	77.2 (3)
Dimethyl Sulfoxide	2.50 (5)	39.5 (7)
Methanol	4.87 (1), 3.31 (5)	49.1 (7)
Methylene Chloride	5.32 (5)	54.00 (5)
Pyridine	8.74 (1), 7.58 (1), 7.22 (1)	150.3 (1), 135.9 (3), 123.9 (5)
Water (D_2O)	4.8	

(Figure-5: NMR solvent signals)

3. Conclusion

On the basis of the data provided the following conclusion can be stated. In the theoretical NMR spectra interpretation solvent plays a very major role. The introduction of solvent molecules improves the theoretical data of nuclei. Here we discussed about different peaks signals of solvent which help to elucidate the structure more accurately. As solvents are very important and expensive, we need to take proper care of them. Here we also discussed about the storage and handling procedure.

Here we have also discussed about the NMR spectrum of two solvents by considering the peak and signals.

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Centurion Journal of Multidisciplinary Research (India)
Volume 8 Number 2 April - September 2018

