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Editor-in-Chief

Dr. Bidhan Chandra Samanta

Department of Chemistry, Mugberia Gangadhar Mahavidyalaya
Bhupatinagar, Purba Medinipur, 721425, West Bengal, India.



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Editorial Preface

It is a great pleasure to announce that Mugberia Gangadhar Mahavidyalaya, Bhupatinagar, Purba Medinipur, West Bengal is going to present the inaugural volume of a new scholarly journal entitled “Science Bulletin”. It is a peer-reviewed and yearly published journal of science departments from an undergraduate college that aims to publish and circulate innovative research articles on the latest developments in all fields of science and technology. This new journal was envisioned and founded to represent the growing needs of science as an emerging and increasingly vital field. Its mission is to become a voice of the science community, addressing researchers in areas ranging from biochemistry to polymer chemistry, from geography to computational and nutritional science, from mathematics to software architecture, presenting verifiable scientific methods, findings, and solutions.

In this issue, we have published ten papers received from remarkable faculties and researchers of Mugberia Gangadhar Mahavidyalaya. The first paper discussed about a Survey of Milk and Milk Products Consumption among School Going Children at Bhagwanpur-II Block Area. The next paper presented about Cancer and dietary remedies: a review. In the third paper, author discussed about Science and Technology of Salt Manufacturing. In the fourth paper, author discussed about Multi-objective Production Inventory System for deteriorating multi-items. The fifth article presented Effectiveness of Amine Functional Polymers as Curing and Toughening Agents for Epoxy Resin. The next paper discussed on Fibonacci numbers in real life applications. The seventh paper described Geography: A Science by Inception. The eighth paper is a project carried on crustacean larva, their life cycle, evolution and importance. The ninth paper deals with “A Comparison Study on Nutritional and Health Status between Slum and Urban Housewives” And the last paper is on “Echinodermata larva, their distribution, habits, characters and phylogeny”. We believe that this issue will give benefits for the development of science and technology and also will be helpful for the young researchers to ignite their innovative minds.

Dr. Bidhan Chandra Samanta
Editor-in-Chief

Preface

It is a great pleasure to announce that Mugberia Gangadhar Mahavidyalaya, Bhupatinagar, Purba Medinipur, West Bengal is going to present the inaugural volume of a new scholarly journal entitled "Science Bulletin". It is a peer-reviewed and yearly published journal of science departments from an undergraduate college that aims to publish and circulate innovative research articles on the latest developments in all fields of science and technology. This new journal was envisioned and founded to represent the growing needs of science as an emerging and increasingly vital field. Its mission is to become a voice of the science community, addressing researchers in areas ranging from biochemistry to polymer chemistry, from geography to computational and nutritional science, from mathematics to software architecture, presenting verifiable scientific methods, findings, and solutions.

In this issue, we have published nine papers received from remarkable faculties and researchers of Mugberia Gangadhar Mahavidyalaya. The first paper discussed about a Survey of Milk and Milk Products Consumption among School Going Children at Bhagwanpur-II Block Area. The next paper presented about Cancer and dietary remedies: a review. In the third paper, author discussed about Science and Technology of Salt Manufacturing. In the fourth paper, author discussed about Multi-objective Production Inventory System for deteriorating multi-items. The fifth article presented Effectiveness of Amine Functional Polymers as Curing and Toughening Agents for Epoxy Resin. The next paper discussed on Fibonacci numbers in real life applications. The seventh paper described Geography: A Science by Inception. The eighth paper is a original article which described a Copper(II) Polymer bridged with Succinate in a di-nuclear paddle-wheel type fashion. The last paper is a project carried on crustacean larva, their life cycle, evolution and importance.

We believe that this issue will give benefits for the improvement and the development of science and technology.

Dr. Bidhan Chandra Samanta

Editor-in-Chief

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A Survey of Milk and Milk Products Consumption among School Going Children at Bhagwanpur-II Block Area

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Abstract

In this study a survey was conducted on milk and milk products consumption among school going children at Bhagwanpur-II Block area. For that, information was collected from 30 male school going children (15 regular and 15 occasional milk and milk product(s) consumer). There was no significant ($p > 0.05$) difference on body mass index, waist hip ratio, mid upper arm circumference, activeness, involvement in extracurricular activity, total sleeping time and total reading time between regular and occasional milk & milk product(s) consumed school going children. But regular milk & milk product(s) consumed school going children were in more stressed condition compare to other group. The regular milk and milk product consumed school going children involved significantly ($p < 0.05$) in low playing time as compare to occasional milk and milk product(s) consumer. It was found that regular milk & milk product(s) consumed school going children suffered less from dental problem, and allergy as compare to other group. Among regular milk & milk product consumed school going children, 73% children were consuming sufficient (250g/day) milk and milk product(s) and among all dairy products consumption of ice-cream was highest.

Keywords: milk, milk products, school going children, Bhagwanpur-II, survey

1. Introduction

The association between good nutrition and school performance of school going children is well established. It is well known that well-fed children are capable to perform better in school; their ability to focus and perform complex tasks improves, as well as improves

their overall ability to learn (Florence *et al.*, 2008; MacLellan *et al.*, 2008). Children who are starving or poorly fed are more lethargic, irritable, easily distracted and at risk for poor academic performance. Undernourished children not only have less learning ability, but also are more likely to be prone to infection and miss more school (Sorhaindo *et al.*, 2009). Beyond effect on learning, unhealthy eating during childhood may hinder with growth and development and increase the risk of chronic disease later in life.

Milk is a powerful boost to meeting children's nutrient needs. Eating well with Canada's Food Guide recommends that children aged 4 to 8 years consume 2 servings of milk and alternatives (such as cheese and yogurt) each day. Youth aged 9 to 13 years need 3 to 4 servings. Milk offers sixteen essential nutrients that help nourish healthy bodies and minds. Children who drink milk tend to have higher intakes of specific nutrients, such as vitamin A, vitamin B12, folate, calcium and magnesium, and have better overall nutritional status than non-milk drinkers (Bowman, 2002). Milk is the main dietary source of vitamin D and most biologically available source of dietary calcium. To develop strong bones during childhood, and help prevent osteoporosis later in life, it's important that children get enough calcium and vitamin D by consuming the milk and milk product.

Bhagwanpur – II Block area is situated in PurbaMedinipur, West Bengal, India. It is a rural area having 179.23 sp.km area and having population of 192130 (in year 2011). Cultivation is the main source of income of the people of this area (Jana *et al.*, 2016; Gayen *et al.*, 2016).

The objective of the study is to survey milk & milk products consumption among school going children of Bhagwanpur-II Block area.

2. Materials and methods

In order to conduct a survey satisfactorily, it is essential to have a well-accepted methodology. The present nutritional survey is carried out in the following procedure by using appropriate methods with the help of previously made survey sheet.

Selection of the subject

The age of the children selected for interview was within 6-12 years. To avoid gender variation only male children were selected. The total numbers of school going children used was 30 (Regular milk and milk product(s) consuming school going children – 15, Occasional milk and milk product(s) consuming school going children - 15) from Bhagwanpur-II Block area.

Anthropometric assessment

Weight

For weight measurement human weighing machine (BATHROOM WEIGHING SCALE, CROWN Classic, Ramon Surgical Company, Delhi) was used. During weight measurement subjects stand on the platform of the machine with minimum clothes and exerting equal pressure on both feet. The weight was taken from the scale with an accuracy of 0.5 kg.

Height

For height measurement anthropometric rod (The Hindustan Mineral Products, Mumbai) was used. Vertical distance from the floor to the vertex (maximum bulge of the top of the head) of the body was measured while standing in stretched erect posture, feet together and firmly placed on the ground, weight equally distributed on both feet, without shoes, looking straight and ahead, palm flat against side of the thigh.

Body Mass Index (BMI)

BMI is a mathematical formula which correlates with the body fat of an individual. The BMI of each individual is calculated from the following formula.

$$\text{BMI (kg/m}^2\text{)} = \frac{\text{Weight (kg)} \text{ Weight (kg)}}{\text{Height (m}^2\text{)} \text{ Height (m}^2\text{)}}$$

Mid Upper Arm Circumference (MUAC)

The circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow.

Waist circumference

Horizontal circumference at the level of the greatest lateral indentation of trunk (i.e. at the level at which the belt is worn) was measured when subject stood erect and abdomen relaxed.

Hip circumference

Horizontal circumference at the level of the hip bone was measured when subject stood erect and heels together.

Waist Hip Ratio (WHR)

It can be measured from the following formula

$$\text{WHR} = \frac{\text{Waist circumference (cm)} \text{Waist circumference (cm)}}{\text{Hip circumference (cm)} \text{ Hip circumference (cm)}}$$

Personal History

Through interview method the information of school going children collected were activeness, merit, mental stress, involved in extracurricular activity, total sleeping time, total reading time, total playing time, different diseases (dental, allergy, respiratory problem), Way of milk & milk product(s) consumption, Reason of not consuming Milk & milk product(s), Percentage of recommended milk & milk product (250g/day) (s) consuming school going children, Consumption of different milk products.

Graphs and statistics

All the graphs (pie and column/bar) used in this article were made by Excel. The data obtained was analyzed and represented as mean value and standard error. To test the significance of the difference between the means student's unpaired t-test has been used.

3. Results and discussions

In the present study it was found that there was no significant ($p > 0.05$) difference between regular and occasional milk & milk product(s) consumed school going children on BMI, MUAC and WHR (Fig 1).

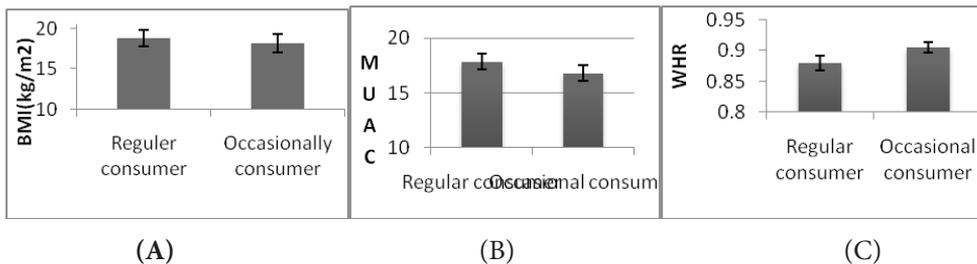


Fig-1 Effect of milk and milk product(s) consumption on (A) Body Mass Index (BMI), (B) Mid Upper Arm Circumference (MUAC) and (C) Waist Hip Ratio (WHR); Vertical bars indicate standard error of mean

It was observed that in both regular and occasionally milk & milk product(s) consumed school going children, 26.7% children were weak. When activeness of both the group was surveyed it was found that in both the group 60% children were active, 33% children were medium active and 7% children were very active. It was noticed that between regular and occasional milk and milk product(s) consumer more percentage of children were very good in regular milk and milk product consumers in merit but in occasional milk and milk product(s) consumer more percentage of students were belong to good and fair in merit (Table 1).

Table 1: Effect of regular milk & milk product(s) consumption on merit of school going children

Merit	Regular milk & milk product(s) consumer	Occasional milk & milk product(s) consumer
Very good (%)	27	13
Good (%)	47	60
Fair (%)	13	20
Poor (%)	13	7

It was found that among regular milk & milk product(s) consumed school going children, 27% children were under low stress, and 73% children were under no stress whereas, among occasionally milk & milk product(s) consumed school going children,

7% children were under low stress, 93% children were under no stress (Table. 2). It may be due to maximum regular milk and milk product(s) consumed school going children were studious and involved themselves more time in study, less time in playing or other entertainments and became stressed.

Table 2: Effect of regular milk & milk product(s) consumption on stress of school going children

Merit	Regular milk & milk product(s) consumer	Occasional milk & milk product(s) consumer
High stress(%)	0	0
Medium stress (%)	0	0
Low stress (%)	27	7
No stress (%)	73	93

It was observed that among regular& occasionally milk & milk product(s) consumed school going children 40% children under regular consumer involved in extracurricular activity, 27% children under occasionally consume involved in extracurricular activity (Fig. 2). Regular milk and milk product consumption gives them extra nutrient to support mental and physical benefit.

There was no significant ($p>0.05$) difference between regular and occasional milk & milk product(s)consumed school going children on total sleeping (Fig. 3) and reading time (Fig. 4).

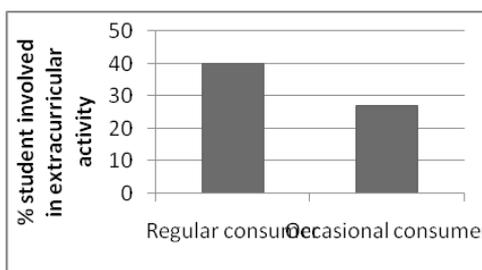


Fig-2 Milk & milk product (s) consumption on extracurricular activity (%) of school going children

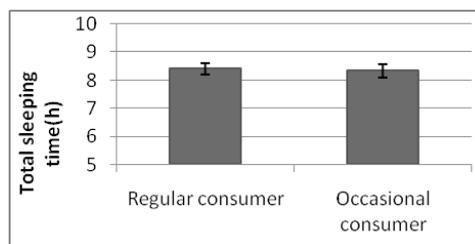


Fig-3 Milk & milk product(s) consumption on total sleeping time/ day of school going children; Vertical bars indicate standard error of mean

The regular milk and milk product consumed school going children involved significantly ($p<0.05$) in low playing time as compare to occasional milk and milk product consumer (Fig. 5). It may be because regular milk consumed children spent more time in their study and as a result they spent lesser time in playing.

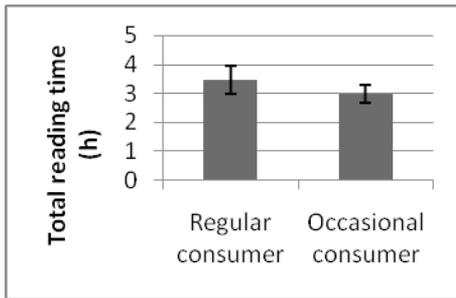


Fig-4 Milk & milk product(s) consumption on total reading time/day of school going children; Vertical bars indicate standard error of mean

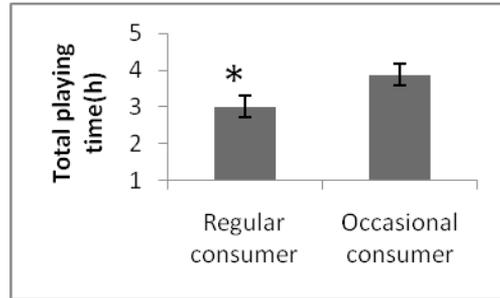


Fig-5 Milk & milk product (s) consumer on total playing time/day of school going children; Vertical bars indicate standard error of mean; $p < 0.05$

It was found that among regular & occasionally milk & milk product (s) consumed school going children 40% children under regular consumer, suffered from dental problem, where as 53.33% children under occasionally consumer suffered in dental problem (Fig. 6). Yoshihara *et al.* (2009) also found in their study on old age people that consumption of milk and milk product reduced root caries. Gueguen and Pointillart (2000) opined that milk contains high levels of protein and calcium, and is often fortified with vitamins A and D; vitamin D enhancing calcium absorption. Moynihan (2002) reported that calcium phosphate and casein present in milk and milk product protected against demineralization of enamel.

It was noticed that among regular & occasionally milk & milk product(s) consumed school going children 33.33% regular consuming children and 46.66% occasionally consuming children suffered in allergy (Fig. 6). Wijgaet *et al.* (2003) found that in pre-school children, milk fat was involved in reduce risk of asthma symptoms.

It was found that both regular & occasionally milk & milk product(s) consumed school going children of 6.66% were suffering from respiratory problem which represented that there was no effect of milk and milk product consumption on respiratory problem (Fig. 6).

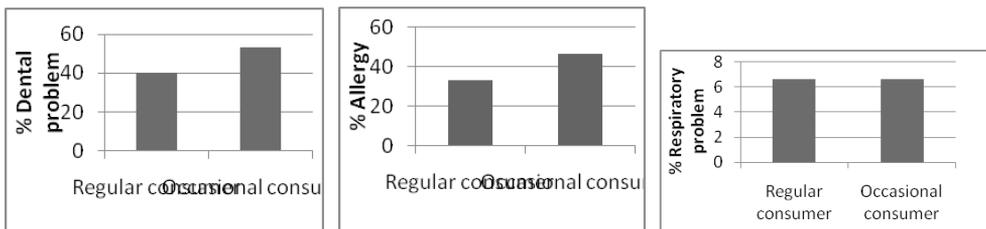


Fig-6 Status of dental problem, allergy and respiratory problem due to regular and occasional consumption of milk and milk product(s) of school going children

It was noticed that regular milk & milk product(s) consumed school going children were consuming milk & milk product with puffed rice 66.66%, biscuit 26.66%, malted food 13.33%, rice 26.66%, roti 20% , bed time directly 20% (Fig. 7). This survey work was conducted in rural area. So, the culture of eating puffed rice with milk was dominant on others.

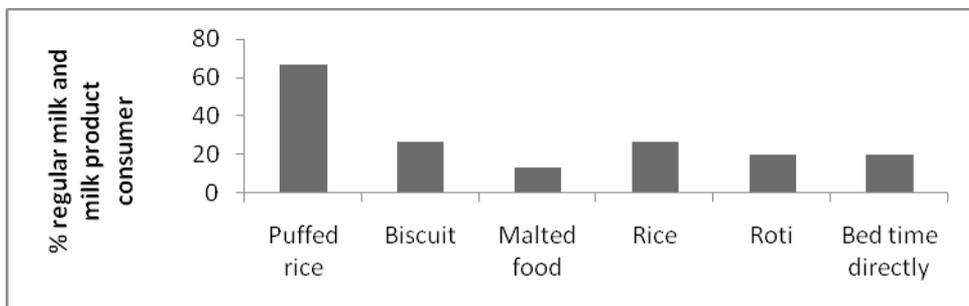


Fig-7 Way of milk & milk product(s) consumption of school going children

It was observed that reason of not regular consuming milk & milk product(s) were allergy of taking milk and milk and milk product, economic problem, difficult to bring from the source and negligence (Fig. 8). The economic problem is the main reason to not consuming milk & milk product(s) regularly.

Among regular milk & milk product consumed school going children,73% children were consuming sufficient (250g/day) milk and milk, 27% were insufficientmilk and milk product consumer (Fig. 9).

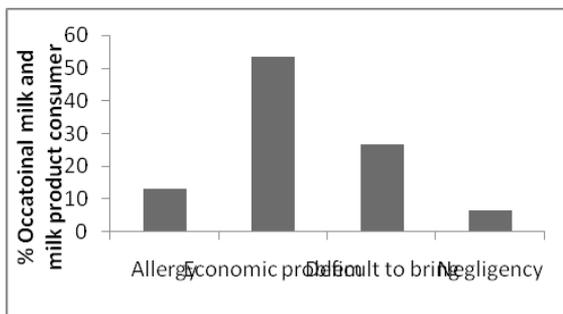


Fig-8 Reason of not consuming Milk & milk product(s)

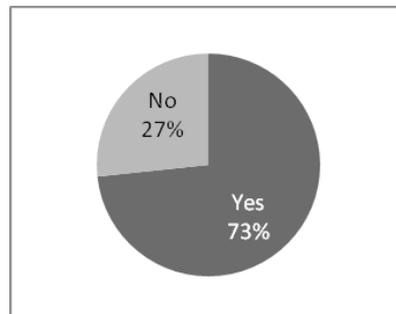


Fig-9 Percentage of recommended milk & milk product(s) (250g/day) consumer among regular milk and milk product consumers of school going children

Among regular milk & milk product(s) consumed school going children many students consuming *dahi*(Table 3). It was due to habit of *dahi* consumption in their home with rice or puffed rice. Percentage of regular *channa* consumption was very low. Only few health conscious and economically rich families provide *channa* to their children. Ice-cream consumption of among students was very high due to their taste preference.

Table 3 : Consumption of different milk products among school going children

	<i>Dahi</i>	<i>Channa</i>	Ice cream
Yes (%)	40	13	47
No (%)	60	87	53

4. Conclusions

In this study it was found that BMI, MUAC, WHR, activeness, concentration, involvement in extracurricular activity, total sleeping time and total reading time did not depend upon regular milk and milk product(s) consumption. But regular consumption of milk and milk product(s) reduced total playing time/day and reduced dental problem and allergy. Maximum school going children consuming sufficient milk and milk product(s) and among all dairy products, maximum school going children preferred ice-cream.

References

1. Bowman, S.A. (2002). Beverage choices of young females: changes and impact on nutrient intakes. *Journal of the American Dietetic Association*.102(9):1234-9.
2. Florence, M.D., Asbridge, M. and Veugelers, P.J.(2008).Diet quality and academic performance.*Journal of School Health*, 78:209-215.
3. Gayen, K.C., Jana, P. and Giri, A. (2016). A survey of tea consumption among people of Bhagwanpur-II block. *International Journal of Trend in Research and Development*, 3(3): 491-493
4. Gueguen, L. and Pointillart, A. (2000).The bioavailability of dietary calcium.*The Journal of the American College of Nutrition*,19 (Suppl. 2): S119–S136.
5. Jana, P., Gayen, K.C. and Giri, A. (2016). A survey of total water consumption among people of Bhagwanpur-II block. *International Journal of Trend in Research and Development*, 3(3): 551-553
6. MacLellan, D., Taylor, J. and Wood, K. (2008).Food intake and academic performance among adolescence.*Canadian Journal of Dietetic Practice and Research*, 69(3):141-144.
7. Moynihan, P.J. (2002). Dietary advice in dental practice. *British Dental Journal*, 193(10): 563-568.
8. Sorhaindo, A. and Feinstein, L. (2009).What is the relationship between child nutrition and school outcomes? Centre for Research on the Wider Benefits of Learning Research Report No.18. Institute of Education, London, (2006).Available at www.learningbenefits.net.

9. Wijga, A.H., Smit, H.A., Kerkhof, M., De Jongste, J.C., Gerritsen, J., Neijens, H.J., Boshuizen, H.C. and Brunekreef, B.(2003). Association of consumption of products containing milk fat with reduced asthma risk in pre-school children: the PIAMA birth cohort study. *Thorax*, 58(7): 567-572.
10. Yoshihara, A., Watanabe, R., Hanada, N. and Miyazaki, H.(2009).A longitudinal study of the relationship between diet intake and dental caries and periodontal disease in elderly Japanese subjects. *Gerodontology*, 26(2): 130-136

Cancer and dietary remedies: a review

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Abstract

Cancer is major health problem and leading cause of death in economically developed countries and the second leading cause of death in developing countries. Cancer risk originates from a diverse range of factors, mainly from constant changes in environment, life-style, dietary habits, ethnicity, sex, age, trans-migratory populations along with automobile exhaust pollutants, smoking, alcohol consumption, solar-UV radiation, physical activity, body mass, genetic susceptibility, etc. Globally, the five most common cancers considered in both sexes were cancers of the lung (1,824,701; 13%), breast (1,676,633; 11.9%), colorectum (1,360,602; 9.7%), prostate (1,111,689; 7.9%), and cervix uteri (527,624; 3.7%), comprising 46.2% of the 28 cancers reported. In 2016, over 1.5 lakh breast cancer cases were reported. Lung cancer cases are nearly 1.14 lakh, comprising 83,000 cases in males and 31,000 cases in females as estimated earlier. Surgical resection is one of the modality of treatment for patients with earlier stages, whereas patients with later stages are treated with combinations of surgery, chemotherapy, and radiation therapy, all of which have significant side-effects. In orthodox regimen, advanced cancer cases are often treated with cisplatin or carboplatin, in combination with gemcitabine, paclitaxel, docetaxel, etoposide or vinorelbine, which affect the normal cells also. So, there is an vital requirement to develop an agent which has target-specific anti-cancer potential with less harm on normal cells. Application of natural medicines in current therapeutic applications is extensively made to treat different human diseases whereas cancer is difficult to cure by any agents till today. Traditional medicinal systems including homeopathy, ayurveda, unani, etc. which are included in the schedule of alternative medicines are now often used against cancer, mostly as a supportive medicine.

Keywords: Cancer, alternative medicines, herbal extracts, extracted components, apoptosis.

1. Introduction

The risk of cancer is now a burning issue throughout the world (Mantena et al., 2006; Arora, 2010). Cancer may affect people of all ages, but the risk for most varieties increases with age, according to a survey conducted by National Cancer Institute. Cancer is caused by both external factors such as tobacco, infectious organisms, chemicals, and radiation and internal factors viz. inherited mutations, hormones, immune conditions, and mutations that occur from metabolism (Kaur et al., 2009) (Fig. 1). International Agency for Cancer Research (2008) has reported approximately 12.7 million new cancer cases and 7.6 million cancer deaths occurred, especially in the ill developed regions (Baliga, 2011).

Among different types of cancers, lung cancer was placed at second position in 2009, according to its occurrence and susceptibility in human (Hsu et al., 2011). Lung cancer is the uncontrolled growth of abnormal cells that start off in one or both lungs; usually in the cells that line the air passages. Many symptoms of lung cancer affect the chest and air passages. These include persistent or intense coughing, pain in the chest shoulder, or back from coughing, changes in colour of the mucus that is coughed up from the lower airways (sputum), coughing up blood, etc. (Fig. 2). The American Cancer Society projected 1,59,390 deaths from lung cancer in 2009, accounting for about 28% of all cancer deaths (American Cancer Society, 2011). Tobacco smoking is a well established fact for lung carcinogenesis; nearly ten-fold increase in lung cancer, specifically NSCLC is attributed to long-term cigarette-smoking in human, although passive tobacco smoking can affect the secondary smokers (Yang et al., 2000; Kometani et al., 2009). Polycyclic aromatic hydrocarbons (PAHs) are the ubiquitous environmental pollutants and chemical genotoxins which are mainly found in tobacco smoke, responsible for lung carcinogenesis (Jiang et al., 2012). Benzo[a]pyrene (BaP) is one of the most well studied PAHs commonly found in cigarette smoke, responsible to induce lung tumour and inflammation in smokers (Li et al., 2001; Sticha, 2000). Although the age-related increase in cancer risk is well-documented, the age-related patterns of cancer are complex. Some types of cancer, like testicular cancer, have early-life incidence peaks, for reasons unknown. Besides, the rate of age-related increase in cancer incidence varies between cancer types with, for instance, prostate cancer incidence accelerating much faster than brain cancer (*de Magalhaes, 2013*) (Fig. 3)

Surgical resection is the only treatment for patients with stage I or II of different cancer types, whereas patients with next two stages are treated with combinations of surgery, chemotherapy, and radiation therapy (Tseng et al., 2008) (Fig. 4). In orthodox regimen, advanced stages of cancer are often treated with cisplatin or carboplatin, in combination

with gemcitabine, paclitaxel, docetaxel, etoposide or vinorelbine like chemotherapies, which have significant side-effects by affecting normal cells (Koshkina et al., 2008). Most types of dreaded cancer are hardly respond to such conventional chemotherapies primarily because of mutations at KRAS, p53 like important regulators involved in normal tissue signalling, often makes it resistant to chemotherapy (Guo et al., 2008). In view of undesirable side-effects of both chemotherapies and radiation therapies, a search is on to find out ways to avoid these by using some alternative therapies that are equally effective but have no or little side-effects.

Make use of natural medicines including herbal and plant elements in the modern therapeutic applications has been widely made to treat different human diseases like diarrhoea, fever, common cold, etc., some of which are now used as alternative therapy against cancer. Furthermore, many phytochemicals such as, flavones, glycosides, catechins etc. isolated from different herbs or plant extracts are now being considered as useful remedies against cancer (Choi et al., 2011). There are many anticancer formulations in ancient and modern medicinal books which should provide a useful guide along with clinical evidences for the identification of new anti-cancer compounds (Cheng et al., 2005). All these aforesaid traditional medicinal systems are included in the regimen of complementary and alternative medicines (CAM). The main advantage of CAM therapies is low cost with lesser side-effects (Rostock et al., 2011). Thus traditional medicinal plant extracts and their active components have re-ignited research for ascertaining and evaluating their scientific roles in cancer treatment. CAMs including homeopathy, acupuncture, aromatherapy, ayurveda, unani, etc. are now gaining importance to cure many hardly cured diseases including cancer for more than 15 years and successfully gained medical, economic and sociological importance (Saini et al., 2011; Evans et al., 2007).

2. Differential organic and inorganic agents involved in cancer cure:

Multiple studies have suggested that fruit and vegetable consumption are protective against lung cancer (Vainio et al., 2006). A relatively recent review of the current evidence by the World Cancer Research Fund and the American Institute for Cancer Research concluded that carotenoid-containing foods are likely protective, and non-starchy vegetables, selenium-containing foods and quercetin (a flavonoid compound)-containing foods might also be protective, based on limited evidence (American Institute for Cancer Research, 2007). A local study has highlighted the protective effect of cruciferous vegetables, in particular in smokers (Bin et al., 2001); the putative protective compounds appear to be isothiocyanates. Other risk factors have also been explored. Using the model of smoking-related lung carcinogenesis, where the effect of smoking is mediated through both direct carcinogenic damage and chronic inflammation, investigators have also considered the role of other possible carcinogens, such as cooking fumes (Ko et al., 2000), smoke emissions from incense (Friborg et al., 2008), mosquito coils (Chen et al., 2008) and wood smoke (Lissowska et al., 2005). Meat-derived carcinogens as a result of cooking or food-processing methods have also been studied (Sinha et al., 2000).

3. Cancer and plant extracts as alternative medicines

Among all herbals, Green Tea (*Camellia Sinensis*), shows affordable protection against most types of cancers like lung, liver, esophagus, forestomach, duodenum, pancreas, colon, and breast.

Green tea is native to China South and Southeast Asia, but it is today cultivated across the world in tropical and subtropical regions. It is an evergreen shrub or small tree belong to family *Theaceae*. Among the mineral kingdom, Sodium selenite is safe, have potential chemopreventive and anticancer effect.

Scutellaria barbata (SB) is a medicinal plant found in the Chinese Pharmacopoeia (Gao et al., 2011) and others. The herb contains flavonone compounds scutellarein, scutellarin, carthamidin, isocarthamidin, and wogonin. A diterpene substance neoandrographolide and a cytotoxic constituent were also isolated from the herb. The gram-positive bacteria, including methicillin-resistant *Staphylococcus aureus*, were more sensitive to the oil than gram-negative bacteria and yeast. The anticancer activity and mechanism of SB extract in human lung cancer cell lines, A549, were investigated. The methylene chloride fraction from SB can induce apoptosis in human leukemia cells, U937, via the mitochondria signaling pathway. It was also suggested that that SB extract reduces tumor volume in smooth muscle cells by inducing a concomitant increase in the rate of apoptosis. For botanicals and herbal preparations, there is a need to approach scientific proof and clinical validation with chemical assay, biological assays, animal models, and clinical trials.

Ganoderma lucidum (or “Lingzhi” in Chinese) has long been recognized by Chinese medical professionals as a valuable herbal medicine in treating a number of different illnesses (Xie et al., 2006). Currently, there are several *Ganoderma lucidum* herbal products available. SunRecome is a commonly used *Ganoderma lucidum* product manufactured by Shanghai Green Valley Pharmaceuticals in China. Previous studies showed that this herbal product could attenuate chemotherapy-induced nausea and vomiting in clinical trials and animal studies. Although human observational data in Chinese literature suggest that *Ganoderma lucidum* possesses an anticancer property, and the active anti-tumor constituents are thought to be on the polysaccharides, the effects of this medicinal mushroom on human colorectal cancer cells has not been evaluated.

Huanglian (*Coptis chinensis*) is an herb that has been widely used in China for several thousand years. It is prepared as an herbal tea from the roots. Huanglian has been used for the treatment of inflammatory conditions accompanied by high fever (Li et al., 2000). This includes pneumonia and infections of the head and face. It is used routinely in China for the treatment of gastroenteritis. Huanglian’s role as an anticancer agent has not been defined. The demonstration of anticancer effects *in vitro* and identification of novel targets would provide a rationale for clinical development of this agent as a whole herb in cancer therapy. Reviewed results indicate that huanglian potently inhibits the growth of gastric, breast, and colon cancer cells *in vitro* in a time- and dose-dependent manner.

Flowers of the plant *Calendula officinalis*, commonly known as “Marigold”, are used in the West and in Asia for their anti-inflammatory properties (Jiménez-Medina et al.,

2006). Phytopharmacological studies of different calendula extracts have shown anti-viral activity, anti-HIV properties of therapeutic interest, and anti-genotoxic properties. In clinical studies, *Calendula* was highly efficacious in the prevention of acute dermatitis in cancer patients undergoing postoperative irradiation. Its cytotoxic effect on tumor cell lines *in vitro* and its anticancer efficacy *in vivo* was briefly outlined 20 years ago. Chemical constituents of *C. Officinalis* include some triterpenes, triterpene oligoglycosides, and flavonol glycosides. The aim of the present study was to evaluate the *in vitro* cytotoxic anti-tumor and immunomodulatory activities of a novel extract of the plant *Calendula Officinalis*.

Sulforaphane (SFN), a potent cancer preventive agent, is a dietary isothiocyanate compound found as a precursor glucosinolate in cruciferous vegetables such as Brussels sprouts, cauliflower, and broccoli (Chen et al., 2012). Interest in this agent has grown in recent years based on its putative beneficial pharmacological effects, which include antioxidant, anti-inflammatory, and antitumor properties.

Berberine is an isoquinoline alkaloid present in the roots, rhizome and stem bark of a number of important medicinal plant species (e.g. *Berberis aquifolium*, *Berberis vulgaris*, *Berberis aristata* and *Tinospora cordifolia* etc.). The potential importance of berberine is indicated by its use in the Indian Ayurvedic (Katiyar et al., 2009), Unani and Chinese systems of medicine since time immemorial. Berberine possesses a wide range of biochemical and pharmacological activities, viz. antidiarrheal, antiarrhythmic and antitumor activities.

Cinnamomum cassia bark is the outer skin of an evergreen tall tree belonging to the family Lauraceae. Its extracts contain several active components such as essential oils (cinnamic aldehyde and cinnamyl aldehyde), tannin, mucus and carbohydrates. They have various biological functions including anti-oxidant, antimicrobial, anti-inflammation, anti-diabetic effects, and anti-tumor activity (AbouEl et al., 2006).

Chelidonium majus L. (Papaveraceae) is a plant of great interest for its use in various diseases in European countries and in Chinese herbal medicines. Crude extracts of various parts such as the root, shoot and leaves have been reported to have several isoquinoline alkaloids, such as, sanguinarine, chelidonine, chelerythrine, berberine and coptisine. Both crude extracts of *C. majus* and purified compounds derived from it have been reported to exhibit interesting anti-viral, anti-inflammatory, anti-tumor and anti-microbial properties both *in vitro* and *in vivo* (Biswas et al., 2002). Besides, inhibitory effect of *Chelidonium majus* herb extract has been reported on growth of keratinocytes in human, and on lipoxygenase activity in mice (Biswas et al., 2008) while stimulatory effect has been reported on bile acid independent flow in isolated perfused rat liver. In the homeopathic mode of treatment, various micro doses (potencies) of *Chelidonium* herb extract are routinely used against several forms of liver disorders, including liver cancer with good effect.

Sulforaphane, an isothiocyanate first isolated from broccoli, has received intense attention for its chemopreventive potential of cancer because it is one of the most potent

inducers of phase II detoxifying enzymes among many natural compounds. It is consistent that although sulforaphane is chemoprotective in wild-type animals, it loses its efficacy in the reduction of benzo[a]pyrene-induced gastric tumors in Nrf2 deficient mice (Yeh and Yen, 2005). Chemoprotection with sulforaphane also resulted in the delayed appearance of tumors. In HT29, a human colon cancer cell line, sulforaphane induces apoptotic cell death with the appearance of proapoptotic protein bax, release of cytochrome c into the cytosol and cleavage of poly(ADP-ribose) polymerase (PARP).

Ursolic acid (UA) is a pentacyclic triterpene compound and exists in medicinal herbs such as *Oldenlandia diffusa* and *Radix actinidiae*. UA has been shown to have the effects of anti-inflammatory, antioxidant, and antitumor (Wang et al., 2011). Studies have found that UA can inhibit the activities of DNA polymerase and DNA topoisomerase and decrease the rate of cell proliferation. Moreover, UA can induce apoptosis of tumor cell by increasing the level of intracellular calcium ion, suppressing the expression of FoxM1, and upregulating of death receptors.

One such plant that has been extensively studied is the medium-sized deciduous tree *Emblica officinalis Gaertn* or *Phyllanthus emblica Linn*. The plant species, which was originally native to India, is today found growing in Pakistan, Uzbekistan, Sri Lanka, South East Asia, China, and Malaysia. Colloquially, they are known as Indian gooseberry tree, emblic myrobalans, and Malacca tree in English and amla in Hindi. All parts of the plant are of use in treating various ailments, but the fruit, which is yellowish-green in colour, globular in shape, fleshy and smooth, striated with an obovate, obtusely triangular six-celled nut, is of immense use in various folk and traditional systems of medicine including against differential cancer (Baliga et al., 2011).

Danthron (1,8-dihydroxyanthraquinone), a naturally occurring component, was isolated from the root and rhizome of *Rheum palmatum L.*, a plant used medicinally for a long time (Chiang et al., 2011). Danthron treatment may, in part, reduce neurotoxicity related to amyloid protein. It was also reported that after daily oral administration of danthron to melanosis coli in the guinea pig large intestine, there was a transient and dose-related wave of apoptosis of the colonic surface epithelial cells. Moreover, danthron induced the Herein, we also explored the roles of caspase cascades, ROS, DNA damage, mitochondrial dysfunction, and the level of Bax/Bcl-2 ratio in danthron-induced apoptosis of SNU-1 human stomach cancer cells.

Astragali radix (AR) is the dried root of *Astragalus membranaceus Bge. Var. mongholicus* and is used as a tonic in the traditional Chinese medicine. It has been used extensively as an adjuvant in cancer treatment and as a phytochemical immune modulator.

The dried tuber of *Typhonium giganteum* is recorded in the Chinese Pharmacopoeia as a traditional Chinese medicine named Baifuzi (Hsu et al., 2011). It has been reported that the chemical components of *T. giganteum* Engl. tubers included β -sitosterol, β -sitosterol-D-glucoside, dl-inositol, cerebroside, etc. Several studies have reported that *T. giganteum* had potent anticancer activity, both *in vitro* and *in vivo*. The aqueous extract from *T. giganteum* tubers induced apoptosis in SMMC-7721 cells via cell cycle arrest in S phase.

The aqueous extract induces apoptosis in MCF-7 cells via cell cycle arrest in S and G2/M phase.

Sulforaphane is an isothiocyanate that has been isolated from saga broccoli as the major phase II enzyme inducer present in organic solvent extracts of this vegetable (Chen et al., 2012). Our interest on sulforaphane stemmed from the observations like it occurs naturally in widely consumed vegetables and at a particularly high concentration in broccoli; through an apoptotic pathway involving typical biochemical and ultrastructural modifications related to programmed cell death.

Artocarpus altilis, known as breadfruit, is a widely known food source but is also commonly used as a folk medicine in Indonesia where it is locally called Sukun. Traditionally, the leaves of Sukun are used for the treatment of various kinds of diseases such as liver cirrhosis, hypertension and diabetes. Scientifically, some biological activities of the extract of this plant have been reported. The methanol/dichloromethane extract from bud covers of sukun was shown to have activity in a cathepsin K inhibition assay (Arung et al., 2009). Recently, a study showed the ethylacetate extract of the leaves had cytotoxic effects on some human cancer cell lines, including human lung adenocarcinoma (SPC-A-1cells), human colon carcinoma (SW-480 cells), and human hepatocellular carcinoma (SMMC-7721 cells) 7, thus indicating that the extract might be a potential anti-cancer agent.

Berberine is an isoquinoline alkaloid present in the roots, rhizome and stem bark of a number of important medicinal plant species (e.g. *Berberis aquifolium*, *Berberis vulgaris*, *Berberis aristata* and *Tinospora cordifolia* etc.). The potential importance of berberine is indicated by its use in the Indian Ayurvedic (Mantena et al., 2006), Unani and Chinese systems of medicine since time immemorial. Berberine possesses a wide range of biochemical and pharmacological activities, viz. antidiarrheal, antiarrhythmic and antitumor activities.

Homeopathic medicines are being practiced as a major alternative system in various diseases including cancer. Although it is widely accepted among people, the effectiveness and the mechanism of these drugs are still controversial. In Homeopathy, the drugs used are in the form of dynamized preparations. Effectiveness of homeopathic medicines *Chelidonium* and *Lycopodium* in ameliorating p-dimethyl aminoazobenzene induced and phenobarbital promoted hepatocarcinogenesis in mice was reported earlier (Pathak et al., 2006). Prostate tumour xenografts were found to be significantly reduced by *Sabal serrulata* (MacLaughlin et al., 2006). Selected homeopathic remedies were reported to significantly slow the progression of cancer and reduce cancer incidence and mortality in Copenhagen rats injected with MAT-LyLu prostate cancer cells (Jonas et al., 2006). *Hydrastis* at different potencies was found to increase the life span of ascites tumour bearing animals (Maliekal, 1997). N-nitrosodiethylamine (NDEA) induced hepatocarcinogenesis in rats was found to be inhibited by *Ruta* 200c, *Hydrastis* 200c and *Lycopodium* 200c. In a clinical study, Pathak et al (2006) found *Ruta* 6c to inhibit glioma growth in brain cancer patients. Homeopathy has been reported as a supportive therapy in cancer. Transplanted

tumours in animals are effective methods to find out the efficacy of the drugs against cancer and several models have been suggested.

Hesperidin belongs to the class of flavonoids called flavanones and is found mainly in citrus fruits. It has several biological functions such as antioxidant, anti-inflammatory, prostaglandin-synthesis inhibition, anti-mutagenic activity, modulation of drug-metabolizing enzymes etc., (Kamaraj et al., 2009). The effects of hesperidin in the prevention and treatment of disease have recently received considerable attention with particular interest in the use of flavonoids as anti-cancer compounds. It has been reported to have several health beneficial effects, including the inhibition of skin tumorigenesis, and of carcinogenesis in the bladder. Additionally, hesperidin suppresses cell proliferation in azoxymethane-induced rat colon carcinogenesis.

The flavolignan, silibinin, is a major constituent in silymarin, an extract of milk thistle (*Silybum marianum*). Recently, silibinin received significant attention for its strong chemopreventive and anticancer efficacy. Silibinin inhibited growth in cancer models of skin, prostate, bladder, and colon (Ramasamy et al., 2011). Silibinin inhibits multiple cytokine-induced signaling pathways that regulate inducible nitric oxide synthase (iNOS) expression in A549 cells, and inhibited the *in vivo* growth of A549 xenografts, and reduced the systemic toxicity of doxorubicin in these studies.

Gallic acid (3,4,5-trihydroxybenzoic acid, GA), a naturally occurring plant phenol, comes from the hydrolysis of tannins, and it has been shown to induce apoptosis in human leukemia HL60RG cells (Ji et al., 2009) and many human cancer cell lines as well as human stomach cancer and colon adenocarcinoma cell lines. Cruciferous vegetables consisting of cabbage, Napa cabbage, broccoli, and cauliflower and their bioactive components, glucosinolates, have been reported to be associated with lowered risks of cancers. The degradation products of glucosinolates such as indole-3-carbinol (I3C) and isothiocyanates, including b-phenylethyl isothiocyanate (PEITC) and benzyl isothiocyanate (BITC), have been shown to possess anticarcinogenic activities, and to induce apoptosis in various cancer cell lines (Huang et al., 2004).

4. Discussions

The present review work constitutes one of the largest surveys to date on the use of alternative therapies in cancer patients. As such, it provides initial evidence of the extent of the use of alternative therapies, their types, reasons behind use or non-use, certain benefits of them, sudden expenses, and commonly observed side-effects. It is shown that alternative remedies in differential cancer patients is the use of medicinal herbal extracts and/or homeopathic preparations, although the usage of differential plants differed by country. More than one-third (35.9%) of the cancer patients reported using some forms of alternative treatments, with little variations in different countries.

So traditional medicinal plant extracts and many active components of them have improved research for ascertaining and evaluating their scientific roles in cancer remediation and successfully gained medical, economical and sociological importance

(Black, 1999). Induction of apoptosis is now considered as one of the major therapeutic approach of reduction and inhibition of cancer development through some signalling cascade. From a thorough analysis of this review work, it would be clear that alternative therapies especially homeopathic remedies have some positive inhibiting property against differential cancer including lung cancer. Incidentally Khuda-Bukhsh (2008) proposed a hypothesis based on many direct and indirect (circumstantial) evidences that one of the mechanisms through which the homeopathic drugs act, might be by the regulation of gene expression (Chakraborty et al., 2012).

But more in depth research works are needed to arrive at a definite conclusion about the precise mechanisms of action of the homeopathic drugs in its different states. Going by the proverb that “there is no smoke without fire”, it can safely be said that this is going to bring more confrontations between the believers and nonbelievers. More research activities with an open mind are warranted on this ‘controversial’ science, so that more evidences to unravel its scientific intricacies may come out.

5. Conclusion

Therefore, from the analysis of degree of differences in various research data discussed in this current aspect of review work it can be claimed that alternative therapies brought in palpable modulatory changes in the parameters of study selected. Taking into considerations of all aspects of this major study, it was revealed that modern alternative treatments form elicited positive response as revealed from the modulatory effects shown by the living organisms. Regarding the mechanism of action, there exist many views and studies were warranted to understand the possible mechanism involved and could act by regulation of expressions of some relevant genes. In conclusion, present research work has clearly shown that alternative remedies opening up possibilities of increasing survivability and longevity of differential cancer patients who are facing some difficulties in conventional treatments, giving them a better way of life with reduction in chemotherapeutic toxicity.

References

1. Mantena SK, Sharma SD, Katiyar SK. Berberine inhibits growth, induces G1 arrest and apoptosis in human epidermoid carcinoma A431 cells by regulating Cdk1-Cdk-cyclin cascade, disruption of mitochondrial membrane potential and cleavage of caspase 3 and PARP. *Carcinogenesis*. 2006;27(10):2018-27.
2. Arora R., Ferlay J., Shin H.R., Bray F., Forman D., Mathers C., Parkin D.M., 2010. Herbal drugs: a cancer chemopreventive and therapeutic perspective. New Delhi, India: Jaypee Brothers Medical Publishers (P) Ltd *Int J Cancer*. 15: 2893-2917.
3. Kaur M, Agarwal C, Agarwal R. Anticancer and cancer chemopreventive potential of grape seed extract and other grape-based products. *J Nutr*. 2009 Sep;139(9):1806S-12S.
4. Baliga MS, Dsouza JJ. Amla (*Embllica officinalis* Gaertn), a wonder berry in the treatment and prevention of cancer. *Eur J Cancer Prev*. 2011 May;20(3):225-39.
5. Hsu HF, Huang KH, Lu KJ, Chiou SJ, Yen JH, Chang CC, Hwang JY. Typhonium blumei extract inhibits proliferation of human lung adenocarcinoma A549 cells via induction of

- cell cycle arrest and apoptosis. *J Ethnopharmacol*. 2011 May 17;135(2):492-500.
6. American Cancer Society. Cancer reference Information. What are the key statistics about lung cancer? www.cancer.org, 2011
 7. Yang SC, Jenq SN, Kang ZC, Lee H. Identification of benzo[a]pyrene 7,8-diol 9,10-epoxide N2-deoxyguanosine in human lung adenocarcinoma cells exposed to cooking oil fumes from frying fish under domestic conditions. *Chem Res Toxicol*. 2000 Oct;13(10):1046-50.
 8. Kometani T, Yoshino I, Miura N, Okazaki H, Ohba T, Takenaka T, Shoji F, Yano T, Maehara Y. Benzo[a]pyrene promotes proliferation of human lung cancer cells by accelerating the epidermal growth factor receptor signaling pathway. *Cancer Lett*. 2009 Jun 8;278(1):27-33.
 9. Jiang Y, Rao K, Yang G, Chen X, Wang Q, Liu A, Zheng H, Yuan J. Benzo(a)pyrene induces p73 mRNA expression and necrosis in human lung adenocarcinoma H1299 cells. *Environ Toxicol*. 2012 Mar;27(4):202-10.
 10. Li D, Firozi PF, Wang LE, Bosken CH, Spitz MR, Hong WK, Wei Q. Sensitivity to DNA damage induced by benzo(a)pyrene diol epoxide and risk of lung cancer: a case-control analysis. *Cancer Res*. 2001 Feb 15;61(4):1445-50.
 11. Sticha KR, Staretz ME, Wang M, Liang H, Kenney PM, Hecht SS. Effects of benzyl isothiocyanate and phenethyl isothiocyanate on benzo[a]pyrene metabolism and DNA adduct formation in the A/J mouse. *Carcinogenesis*. 2000 Sep;21(9):1711-9.
 12. *de Magalhaes JP (2013). "How ageing processes influence cancer". Nature Reviews Cancer. 13 (5): 357-65.*
 13. Tseng CL, Wu SY, Wang WH, Peng CL, Lin FH, Lin CC, Young TH, Shieh MJ. Targeting efficiency and biodistribution of biotinylated-EGF-conjugated gelatin nanoparticles administered via aerosol delivery in nude mice with lung cancer. *Biomaterials*. 2008 Jul;29(20):3014-22.
 14. Koshkina NV, Waldrep JC, Roberts LE, Golunski E, Melton S, Knight V. Paclitaxel liposome aerosol treatment induces inhibition of pulmonary metastases in murine renal carcinoma model. *Clin Cancer Res*. 2001 Oct;7(10):3258-62.
 15. Guo W, Wu S, Liu J, Fang B. Identification of a small molecule with synthetic lethality for K-ras and protein kinase C iota. *Cancer Res*. 2008 Sep 15;68(18):7403-8.
 16. Choi WH, Chu JP, Jiang MH, Baek SH, Park HD. Effects of fraction obtained from Korean Corni Fructus extracts causing anti-proliferation and p53-dependent apoptosis in A549 lung cancer cells. *Nutr Cancer*. 2011;63(1):121-9.
 17. Rostock M, Naumann J, Guethlin C, Guenther L, Bartsch HH, Walach H. Classical homeopathy in the treatment of cancer patients--a prospective observational study of two independent cohorts. *BMC Cancer*. 2011 Jan 17;11:19.
 18. Saini A, Berruti A, Capogna S, Negro M, Sguazzotti E, Picci RL, Campagna S, Dongiovanni V, Dogliotti L, Furlan PM, Ostacoli L. Prevalence of complementary/alternative medicines (CAMs) in a cancer population in northern Italy receiving antineoplastic treatments and relationship with quality of life and psychometric features. *Qual Life Res*. 2011 Jun;20(5):683-90.
 19. Evans M, Shaw A, Thompson EA, Falk S, Turton P, Thompson T, Sharp D. Decisions to use complementary and alternative medicine (CAM) by male cancer patients: informa-

- tion-seeking roles and types of evidence used. *BMC Complement Altern Med.* 2007 Aug 4;7:25.
20. Vainio H and Weiderpass E. Fruits and vegetables in cancer prevention. *Nutrition and Cancer* 2006; 54(1): 111-42.
 21. World Cancer Research Fund International. Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington, USA. American Institute for Cancer Research, 2007.
 22. Bin Z, Seow A, Lee EJD, et al. Dietary isothiocyanates, glutathione-S transferase -M1 -T1 polymorphisms and lung cancer risk among Chinese women in Singapore. *Cancer Epidemiol Biomarkers Prev* 2001; 10:1063-7.
 23. Ko YC, Cheng LS, Lee CH, et al. Chinese food cooking and lung cancer in women nonsmokers. *Am J Epidemiol* 2000; 151:140-147; Yu IT, Chiu YL, Au JS, et al. Dose-response relationship between cooking fumes exposures and lung cancer among Chinese nonsmoking women. *Cancer Res* 2006; 66: 4961-4967.
 24. Friberg JT, Yuan JM, Wang RW, et al. Incense use and respiratory tract carcinomas. *Cancer* 2008; 113:1676-84.
 25. Chen SC, Wong RH, Shiu LJ, et al. Exposure to mosquito coil smoke may be a risk factor for lung cancer in Taiwan. *J Epidemiol* 2008; 18:19-25.
 26. Lissowska J, Bardin-Mikolajczak A, Fletcher T, et al. Lung cancer and indoor pollution from heating and cooking with solid fuels. *Am J Epidemiol* 2005; 162:326-33.
 27. Sinha R, Kulldorff M, Swanson CA, et al. Dietary heterocyclic amines and the risk of lung cancer among Missouri women. *Cancer Res* 2000; 60: 3753-6.
 28. AbouEl Hassan MA, Braam SR, Kruyt FA. Paclitaxel and vincristine potentiate adenoviral oncolysis that is associated with cell cycle and apoptosis modulation, whereas they differentially affect the viral life cycle in non-small-cell lung cancer cells. *Cancer Gene Ther.* 2006 Dec;13(12):1105-14. Epub 2006 Jul 14.
 29. Gao J, Morgan WA, Sanchez-Medina A, Corcoran O. The ethanol extract of *Scutellaria baicalensis* and the active compounds induce cell cycle arrest and apoptosis including upregulation of p53 and Bax in human lung cancer cells. *Toxicol Appl Pharmacol.* 2011 Aug 1;254(3):221-8.
 30. Xie JT, Wang CZ, Wicks S, Yin JJ, Kong J, Li J, Li YC, Yuan CS. Ganoderma lucidum extract inhibits proliferation of SW 480 human colorectal cancer cells. *Exp Oncol.* 2006 Mar;28(1):25-9.
 31. Li XK, Motwani M, Tong W, Bornmann W, Schwartz GK. Huanglian, A chinese herbal extract, inhibits cell growth by suppressing the expression of cyclin B1 and inhibiting CDC2 kinase activity in human cancer cells. *Mol Pharmacol.* 2000 Dec;58(6):1287-93.
 32. Jiménez-Medina E, García-Lora A, Paco L, Algarra I, Collado A, Garrido F. A new extract of the plant *Calendula officinalis* produces a dual *in vitro* effect: cytotoxic anti-tumor activity and lymphocyte activation. *BMC Cancer.* 2006 May 5;6:119.
 33. Chen MJ, Tang WY, Hsu CW, Tsai YT, Wu JF, Lin CW, Cheng YM, Hsu YC. Apoptosis Induction in Primary Human Colorectal Cancer Cell Lines and Retarded Tumor Growth in SCID Mice by Sulforaphane. *Evid Based Complement Alternat Med.* 2012;2012:415231.
 34. Katiyar SK, Meeran SM, Katiyar N, Akhtar S. p53 Cooperates berberine-induced growth inhibition and apoptosis of non-small cell human lung cancer cells *in vitro* and tumor

- xenograft growth *in vivo*. *Mol Carcinog*. 2009 Jan;48(1):24-37.
35. AbouEl Hassan MA, Braam SR, Kruyt FA. Paclitaxel and vincristine potentiate adenoviral oncolysis that is associated with cell cycle and apoptosis modulation, whereas they differentially affect the viral life cycle in non-small-cell lung cancer cells. *Cancer Gene Ther*. 2006 Dec;13(12):1105-14. Epub 2006 Jul 14.
 36. Biswas SJ, Khuda-Bukhsh AR. Effect of a homeopathic drug, Chelidonium, in amelioration of p-DAB induced hepatocarcinogenesis in mice. *BMC Complement Altern Med*. 2002;2:4.
 37. Biswas SJ, Bhattacharjee N, Khuda-Bukhsh AR. Efficacy of a plant extract (Chelidonium majus L.) in combating induced hepatocarcinogenesis in mice. *Food Chem Toxicol*. 2008 May;46(5):1474-87.
 38. Yeh CT, Yen GC. Effect of sulforaphane on metallothionein expression and induction of apoptosis in human hepatoma HepG2 cells. *Carcinogenesis* 2005; 26(12):2138–2140.
 39. Wang X, Zhang F, Yang L, Mei Y, Long H, Zhang X, Zhang J, Qimuge-Suyila, Su X. Ursolic acid inhibits proliferation and induces apoptosis of cancer cells *in vitro* and *in vivo*. *J Biomed Biotechnol*. 2011;2011:419343.
 40. Chiang JH, Yang JS, Ma CY, Yang MD, Huang HY, Hsia TC, Kuo HM, Wu PP, Lee TH, Chung JG. Danthron, an anthraquinone derivative, induces DNA damage and caspase cascades-mediated apoptosis in SNU-1 human gastric cancer cells through mitochondrial permeability transition pores and Bax-triggered pathways. *Chem Res Toxicol*. 2011 Jan 14;24(1):20-9.
 41. Arung, E.T., Wicaksono, B.D., Handoko, Y.A., Kusuma, I.W., Yulia, D. Sandra, F., Anti-cancer properties of diethylether extract of wood from sukun (*artocarpus altilis*) in human breast cancer (T47D) cells. *Trop. J. Pharm. Res*. 2009, 8, 317-324.
 42. Pathak S, Kumar Das J, Jyoti Biswas S, Khuda-Bukhsh AR. Protective potentials of a potentized homeopathic drug, Lycopodium-30, in ameliorating azo dye induced hepatocarcinogenesis in mice. *Mol Cell Biochem*. 2006 Apr;285(1-2):121-31.
 43. Jonas WB, Gaddipati JP, Rajeshkumar NV, Sharma A, Thangapazham RL, Warren J, Singh AK, Ives JA, Olsen C, Mog SR, Maheshwari RK. Can homeopathic treatment slow prostate cancer growth? *Int Cancer Therp*. 2006; 5(4): 343-349.
 44. Maliekal TP (1997). Antineoplastic effects of 4 homeopathic medicines. *Br Homeopath J*, 86(2), 90-1.
 45. Kamaraj S, Ramakrishnan G, Anandakumar P, Jagan S, Devaki T. Antioxidant and anticancer efficacy of hesperidin in benzo(a)pyrene induced lung carcinogenesis in mice. *Invest New Drugs*. 2009 Jun;27(3):214-22.
 46. Ramasamy K, Dwyer-Nield LD, Serkova NJ, Hasebroock KM, Tyagi A, Raina K, Singh RP, Malkinson AM, Agarwal R. Silibinin prevents lung tumorigenesis in wild-type but not in iNOS-/- mice: potential of real-time micro-CT in lung cancer chemoprevention studies. *Clin Cancer Res*. 2011 Feb 15;17(4):753-61.
 47. Ji BC, Hsu WH, Yang JS, Hsia TC, Lu CC, Chiang JH, Yang JL, Lin CH, Lin JJ, Suen LJ, Gibson Wood W, Chung JG. Gallic acid induces apoptosis via caspase-3 and mitochondrial-dependent pathways *in vitro* and suppresses lung xenograft tumor growth *in vivo*. *J Agric Food Chem*. 2009 Aug 26;57(16):7596-604.
 48. Huang S, Armstrong EA, Benavente S, Chinnaiyan P, Harari PM. Dual-agent molecular

- targeting of the epidermal growth factor receptor (EGFR): combining anti-EGFR antibody with tyrosine kinase inhibitor. *Cancer Res.* 2004, 1;64(15):5355-62.
49. Black WC. (1999). *Cancer Screening: theory and practice*. Kramer BS, Gohagan JK and Prorok PC (eds). New York: Marcel Dekker, Inc., pp. 327 ± 377.
50. Chakraborty D, Samadder A, Dutta S, Khuda-Bukhsh AR. Antihyperglycemic potentials of a threatened plant, *Helonias dioica*: antioxidative stress responses and the signaling cascade. *Exp Biol Med (Maywood)*. 2012;237(1):64-76.

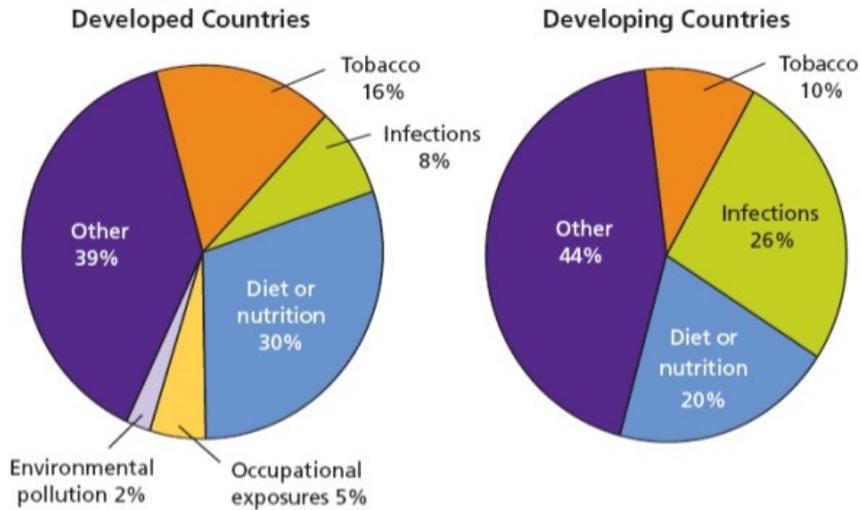


Figure 1: Proportion of cancer causes by major risk factors and level of economic development (Cancer Atlas, 2006)

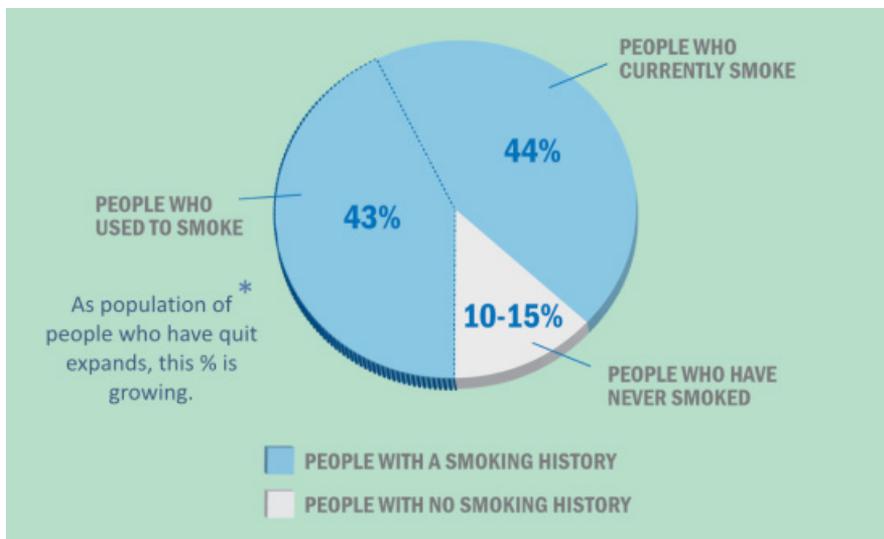


Figure 2: Lung cancer risk which can affect any one.

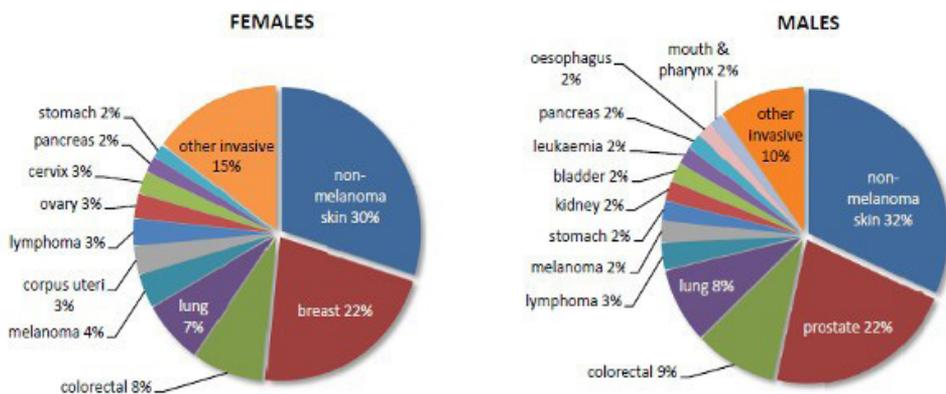


Figure 3: Relative frequency of the main invasive cancers diagnosed, 2009-2011

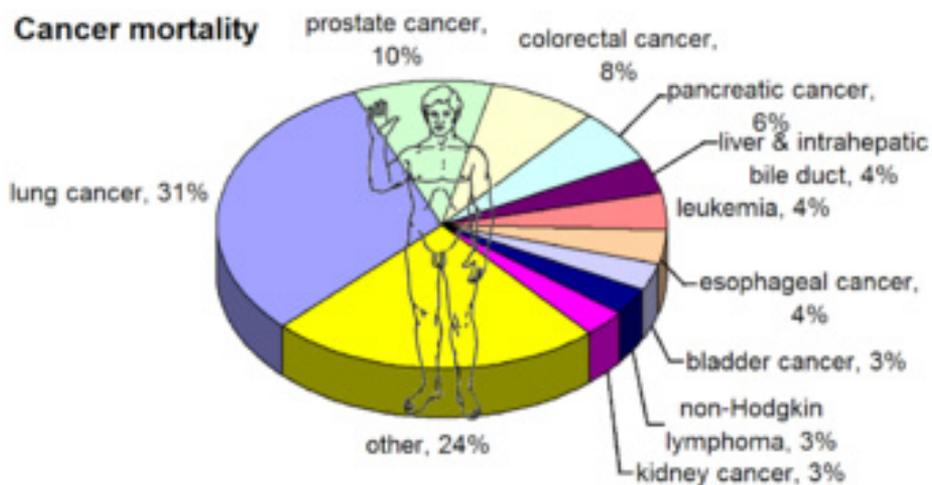


Figure 4: Types of cancer and their mortality rate.

Science and Technology of Salt Manufacturing

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Abstract

Since salt is used in large scale as raw material for the heavy chemical industries and is also used as a food for live stocks and human consumption, so easier and efficient methods for the production of salt in larger scales are extremely necessary to be developed. This study intends to focus on science and technology involved in salt manufacturing throughout India and abroad. The purpose of this study is to provide information to the researchers and students with the relevant secondary data available in the latest reports, documents etc published by the concerned central and state government department and other semi-government and non-government organization and basically by the experts and researchers in this field. It describes the manufacturing processes, factors affecting these processes along with the detailed solar evaporation method for salt manufacturing.

Keywords: Salt-manufacturing, technology, solar evaporation

1. Introduction

Common salt or Sodium chloride is an inorganic substance which is widely distributed in the earth. It is found in varying concentrations in all rocks and clay in earth's crust, in all animal and vegetable life, and in water in all rivers, springs, lakes and the sea. Its concentration is very high in the sea water and in some rocks. The main inexhaustible source of common salt is the sea. The continuous cycle or evaporation of water from the sea leading to rainfall on the land and its return to the sea, laden with dissolved salt(extracted from the earth), has built up the salinity of the sea. The composition of the sea water may not vary much as far as the major components are concerned. The degree of Sodium Chloride can be taken as more or less same throughout the entire sea under normal conditions. The rock salt deposits of the world, which are in the dry and arid areas, contain the best type of salt.

2. Salt Manufacturing Processes and Technologies involved

Salt can be manufactured by the processes stated below.

- a. Solar evaporation of sea water and natural brine from lakes/wells (Solar Evaporation methods).
- b. Artificial evaporation of brine in pans (Which are kept open to the atmosphere either by direct fire or by steam heat (Open pan Evaporation method).
- c. Evaporation of brine by making use of multiple-effect evaporators (Vacuum Pan Evaporation methods).
- d. Chilling of sea water until the ice solidifies, leaving concentrated brine then evaporated to obtain salt (Freezing method), This method is in much use in the North European countries having very cold climate.
- e. Mining rock salt either by dry mining methods or by injecting water through tubes sunk into salt deposits. From the saturated brine, salt is recovered by Artificial evaporation.

These methods are utilized in different degrees depending upon the prevailing climatic conditions, the geographical location of the sources, and the advancement of technology.

In the Western world, where prolonged dry weather is uncommon, solar evaporation of either sea water or natural brine is not much feasible and salt is produced mainly by dry mining of rock salt or by artificial evaporation of brine. On the other hand, in the tropical countries, where long dry periods exist, manufacture by the Solar Evaporation method is resorted to.

In the USA, which is today the largest producer of salt in the world, the production of salt by the Solar Evaporation method constitutes less than four per cent of its total annual production. Notwithstanding the technological advancement in the artificial methods of evaporation, salt manufacture by the Solar Evaporation method is still used in the California region. Similarly, in some of the European countries like Spain, Italy and France, where long dry season exists in the coastal areas, salt is produced by solar evaporation of sea water. In India, the entire salt production, with the exception of the negligible quantity of rock salt (produced at the Mandi Mines, Himachal Pradesh), is obtained by the Solar Evaporation method because nature has endowed India with a long sea coast with long periods of dry weather which aid natural evaporation. In fact, nature has so designed the climate for India that the manufacture of salt the Solar Evaporation method in one or the other part of the country is possible almost round the year. In India, particularly in Purba Medinipur, West Bengal, the Solar Evaporation method is of much importance as compared to the artificial evaporation methods and mining.

3. Factors affecting salt-manufacturing

The factors which are of significance in the manufacture of salt are discussed in brief below. The technology of salt-manufacturing depends largely on the physical laws of

evaporation, solubility and crystallization. Evaporation is the chief operation involved in the process of concentration of brine up to a stage at which it is saturated. The major factors which affect the solar evaporation process are a) continuity of brine supply, b) initial density of the brine, c) dissolved solid, d) solubility, e) availability of land and its topography, f) impermeability of the soil, g) surface of exposure, h) wind velocity, i) temperature, j) humidity, k) vapor pressure and temperature, l) rainfall distribution, m) security against dust storm and flood, n) infrastructure and labor, etc. Some of these factors have been discussed, in brief, below.

- 3.1 Continuity of brine supply :** The supply of brine is of importance, especially in places where the brine is taken from pits or wells. For example, at the Sambhar Lake, brine is obtained by the dissolution of salt by rain water. The production at the Sambhar Lake often fluctuates because of the failure of the brine supply in the years of scanty rainfall.
- 3.2 Initial density of the brine :** The layout of salt works depends on the initial concentration of the brine. When the concentration varies (e.g. during the hot months when evaporation is more and rapid), care has to be taken to adjust the area reserved for the concentration of the brine before it is passed into the crystallizer bed in which salt is separated out.
- 3.3 Dissolved solid :** The presence of salt in the solution alters the vapor pressure of the liquid. When salt does not itself exert any pressure or is not volatile, it lowers the vapor pressure of the solution. The rate of evaporation, therefore, decreases with the rise in concentration of salt in the solution. Weak brine evaporates more than strong brine at a given time.
- 3.4 Solubility :** As a general rule, solubility of a solid in a liquid increases with rise in temperature. The rate of increase differs widely for different substances. The solubility of common salt is, however, fairly constant in water from 0 C to 100 C. The increase in solubility, for this range of temperatures, is only 1.5%. If one examines the solubility at the temperatures prevailing in the salt producing areas, which normally do not go below 10 C or rise above 45 , the range of variation will be found to be only 0.5%.
- 3.5 Impermeability of soil :** The degree of impermeability of soil is also an important aspect. It determines the amount of leakages. With a rise in the concentration, the prevention of leakages becomes increasingly important. Another matter of significance is that the soil has to be such that it does not impart colour to the brine or to the crystals as impurities from the soil tend to get mixed up with the crystals during each handling. Besides, the soil conditions should be such that the dilution of the brine by lateral infiltration of water does not occur.
- 3.6 Surface of exposure :** Evaporation is increased substantially by allowing brine to flow over a wide area with a gentle gradient. In this manner, the brine keeps turning over so that a fresh surface is exposed each time leading to a higher rate of evaporation. Sometimes, this effect is also produced artificially by lifting the

brine is not compensated by adequate increase in evaporation. Another method is to throw up the brine in sprays so that the droplets which form the spray during its rise and fall may produce a large surface of exposure and more evaporation. This procedure, however, involves considerable additional cost and the results obtained so far are not encouraging.

- 3.7 Wind velocity :** The rate of evaporation is higher when the velocity of the wind increased and it drops considerably when there is no breeze. A wind of uniform velocity is of greater importance for promoting evaporation as compared to occasional spurts of high-velocity winds, interspersed with periods of calm air. A high wind velocity may cause a wave effect if the depth of brine is adequate and there is a sufficient expanse of water which in turn affects the accretion of crystals causing small-sized crystals.
- 3.8 Temperature :** Output of salt is affected by the average daily temperature during the entire span of the manufacturing season as the extent of evaporation is dependent upon the temperature. Besides the temperature evaporation is also dependent upon the relative humidity.
- 3.9 Vapor pressure and temperature :** In every liquid, there is a certain amount of vapour, the pressure of which is known as the vapour pressure. This rises with the rise in temperature. When it is equal to the atmospheric pressure, the liquid begins to boil and evaporate. The tendency of the liquid to evaporate is checked by its vapour pressure and the factors which increase or decrease the vapour pressure really increase or decrease the evaporation of the liquid. Atmospheric air has always a certain amount of water vapour in it. At any given temperature, there is a limit beyond which air will not absorb water vapour. When air comes into contact with an aqueous solution, it takes up more water vapour till the limit for that temperature is reached. The extent of evaporation depends on the margin of difference between this limit and the water vapour content of the air. The higher the vapour content or humidity the lesser the evaporation.
- 3.10 Rainfall distribution :** For the manufacture of solar salt, the occurrence of rainfall is of much importance. When it occurs during the manufacturing season, it interferes with the production process by diluting the brine and reducing evaporation.

4. Detail description of solar evaporation method

The solar Evaporation method (the cheapest scientific method which is much in use for salt production from the saline water) has been discussed in some detail below.

Salt was most probably first found as incrustation on exposed sea weeds or shore rocks. However, the first substantial salt supply for human beings was from natural deposits as a result of solar evaporation of shallow sea water pools this was followed by deliberate impounding of sea water in shallow lagoons to be evaporated by the sun's heat. This was the beginning of the solar Evaporation method. Experience gained was assimilated to develop the process further.

For the manufacture of salt by the solar evaporation of sea water, knowledge of the composition of sea water is necessary. Considerable research has been done in this connection by the Italian scientist, Dr. Usiglic. In India, Kapilram H. Vakil has done a lot of research in this field and is considered as a pioneer in the field of modern salt technology.

One liter of sea water contains 35 Gms. of dissolved salt and brine concentration is expressed by a scale known as the "Baume Scale" (Bé). The dissolved salts contained in sea water are separated out one after another the least soluble comes out first and the most soluble comes out last. The order of separation of the dissolved salts depends on their relative solubility-Calcium Carbonate being the least soluble, the magnesium salt, being the most soluble, are obtained at the first stage and the last stage respectively.

Literature in this field states that, in the deep ocean, the percentage of salt in water is generally 3 Bé in the coastal areas, the percentage of salt varies from 1 Bé to 2 Bé (depending on the season). When the percentage of salt in water comes to 26 Bé salt is separated out from water and deposited.

Manufacture of salt by solar evaporation of sea water requires storing of sea water requires storing of sea water in large reservoirs or brine ponds at the time of high tide or by pumping. A series of ponds called condensers are constructed. These are protected by dykes to contain the evaporating sea water and to prevent dilution by inundation during high tides. The layout of the series of condensers is so planned as to provide a zigzag path for the brine, thus, allowing for a uniform increase in the concentration of the entire volume of sea water handled. Maximum use is made of the natural gradients and wind energy to assist the flow of the evaporating brine. Drainage channels are also constructed as outlets for the 'not- useful' water flowing back to the sea during the monsoon. The series of ponds are known as (i) Reservoir, ii) Condensers and iii) Crystallizers. The layout of ponds and the saline water flow circuit are based largely on elevation contours and topography of the area. The concentrating ponds are made as large as is consistent with the maintenance of the desired pond depth and prevention of formation of dead areas or short circuiting. The reservoirs should be deep since their main function is to store brine and maintain a steady brine supply to the concentrating ponds. In an ideal layout, the reservoirs are located on the lowest available land which are close to the brine intake point and the crystallizers are located at the other extreme end. The concentrating ponds are located in between.

From the final section of the series of condensers saturated brine is pumped into smaller evaporation pans known as crystallizers where the salt crystallizes. Here the density increases and about 80 % of the Sodium Chloride (Salt) present in the sea water solidifies. The crystallizers, where the deposition of salt takes place, are the most important part of a salt-manufacturing unit. They constitute not less than 8 % of the area of such a unit. The soil in the crystallizers must necessarily be impervious. The crystallizers must necessarily be impervious. The crystallizers are rectangular in shape, uniform in size and even in level. The beds are well consolidated and neatly maintained. The shorter dimension of a crystallizer is aligned in the direction of wind to maximize evaporation. The preparation of the crystallizers, before they are charged with 25 inch high-density brine, is an important operation done manually and consists of various

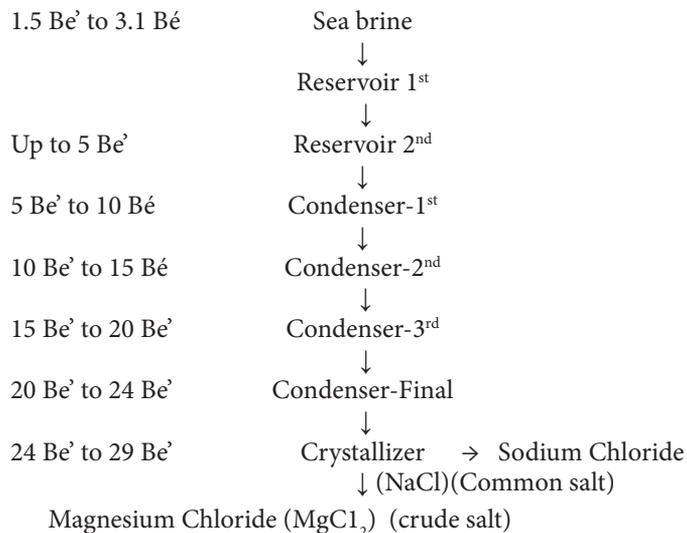
stages-removing the slush, leveling paddling, spraying sand and tamping with mallets, rolling consolidation. The normal size of a crystallizer would be 30M x16M, the upper limit being 100 M x 30 M. manual harvesting involves removal of salt with picks and shovels and conveying it to the nearby platform in baskets. The work is arduous and needs skill to collect the salt without mud.

There are two methods of charging the crystallizers, viz., i) Single Irrigation method and ii) Multiple Irrigation method.

In the first method, high-density brine is charged into the crystallizers and salt is harvested when the density reaches 29 Bé. The bitterns are allowed to remain in the pass and salt is collected. The salt manufactured by this method are of two kinds-light or Map variety and heavy or Wazni variety. The Mapi variety is obtained by charging the crystallizers with saturated brine to a depth of 1inch to 2 inch while the other variety is obtained by charging saturated brine to a depth of 2 inch to 3 inch. A third variety, known as Wuppa, is also manufactured. For this, a crystallizer is divided into small sections. Salt flakes are formed which gradually settle down.

In the Multiple Irrigation method, the crystallizer is charged with saturated brine to a depth of 4 inch to 5 inch and is periodically replenished to make up for evaporation. The crust is allowed to grow into a layer of 3" to 9". Care is taken so that the density of the brine in the crystallizer does not rise above 29 Bé. The salt is harvested 3 to 4 times only during the season. The salt from the crystallizers is transported by trolleys to the works where it is first washed through mechanical vibratory screens to reduce the more soluble impurities, viz magnesium and potassium salts. This washed salt is then stacked and kept open throughout the monsoon season for the purpose of natural purification by rain washing. Then such salt is suitably iodised for human consumption.

The chart is given below given an idea of the brine feeding and salt-manufacturing process in West Bengal.



Conclusion : Solar evaporation method has been proved to be an easier and efficient method for the production of salt in larger scales. This method has been found to decrease the effect of rain fall, concentration of brine, depth of the brine solution on the amount of production. This article highlights not only the processes but also describes various factors which affect these manufacturing processes. So this study must be helpful to the researchers for further improvement of the salt manufacturing processes.

References :

1. Ratton, J. J. L. “*A handbook of common salt*”, Higginbottom & Co. Madras, 1877.
2. Bhatt, M.P and Bokil, R.K, “*Salt Industry in India from Fifties and Eighties: A Brief Review*”, CSMCRI, Bhavnagar, India, 1982.
3. Sinha, N. K (Ed), “*Midnapur salt papers Hijli Land Tamluk*”, Calcutta 1954.
4. Report of the Working Group of Salt Technology, Salt Commissioner, Government of India, Jaipur, India, 1984.
5. Report of the Study Group on Cost of Salt Iodisation and Packing. Salt Commissioner, Government of India, Jaipur, India, 1985.

Multi-objective Production Inventory System for deteriorating multi-items

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Abstract:

A multi-objective model for deteriorating items under a production inventory system has been developed. The items deteriorate at a constant rate, the demand depends on time at that instant, shortages are not allowed and total storage space is limited. Here, for the first time, objectives for operating costs of the items have been expressed as an integral and minimized alongwith a resource constraint using Pontryagin's Optimal Control policy and compromise solutions of the multi-objective production-inventory problems are obtained by goal attainment method and Pontryagin's Optimal Control policy. Finally numerical examples are provided to illustrate the system and the results from two methods are compared.

Keywords: Multi-item inventory, Multi-objectives, Deteriorating items, Dynamic Demand, Optimal Control

1. Introduction:

Since the development of EOQ model by Harris[1], a lot of research works has been reported in the literature(cf. Hadly and Whitin [2], Naddor [3], etc.). In the classical inventory models, normally static lot size models are formulated. But, because of the manufacturing environment, the static models are not adequate in analyzing the behaviour of such systems and in designing the optimal policies for their control. For this reason, dynamic models of production-inventory systems have been considered by some researchers (cf. Hu and Loulon[4], Kirk[5], Hu and Dong [6], etc). In these models, demand and/or production are assumed to be continuous functions of time. To best of our knowledge, all of them have been formulated as a single objective model. Till now, none has considered a multi-objective dynamic model for deteriorating multi-items with resource constraints.

During the last two decades, many researchers (cf. Bhunia and Maiti [8], Mandal and Maiti [9], Giri and Chaudhuri [10], etc.) have given considerable attention to the

area of the inventory of deteriorating/defective/perishable units, since the life time of an item is not infinite while it is in storage and/or all units can't be produced exactly as per the required specifications. They considered the deterioration to be constant or linearly dependent on time or stock.

In this paper, a multi-objective multi-item production-inventory control dynamic problem has been formulated and solved under storage capacity constraint. Here, the deterioration, stock, production and demand are continuous functions of time. The relevant inventory costs of the system are production and holding costs. Initially the business of each item is considered separately under a single management and an approximate value for the operating cost of each item is evaluated by distributing storage space equally for each item. Here, for the first time, objectives for multi-items' operating costs have been expressed as an integrand and is minimized formulating the problem as an optimal control problem. Compromise solutions of the multi-objective production-inventory problems are obtained by goal attainment method and Pontryagin's Optimal Control policy. The optimum production and stock levels are determined for different demand functions. The model is illustrated through several numerical examples and the results from two methods are compared.\

2. Model Formulation :

For a deteriorating multi-item inventory control model, following assumptions and notations are used.

Assumptions:

For i-th item, it is assumed that.

- (1) Demand rate is time dependent.
- (2) Deterioration rate is known and constant.
- (3) Shortages are not allowed.
- (4) Deterioration of units occurs only when the item is effectively in stock and there is no repair or replacement of deteriorated units over the period $[0, T]$.
- (5) Unit production cost is constant.
- (6) The inventory level, deteriorating units, production and demand are assumed to be continuous function of time.
- (7) This is a single period inventory model with known finite time period.

Notations :

n = number of items.

M = maximum space available for storage.

T = time length of the cycle.

λ = Lagrange multiplier.

For the i -th ($i=1, \dots, n$) item,

$U_i(t)$ = production rate at time t .

u_i = upper bound of $U_i(t)$

$X_i(t)$ = the inventory level at time t .

α_i = rate of deterioration.

$D_i(t)$ = time dependent demand ($= d_{i1} + d_{i2}t$).

C_{ui} = unit production cost.

h_i = unit holding cost per unit item.

λ = Lagrange multiplier.

a_i = storage area per unit item.

$p_i(t)$ = adjoint function.

3. Optimal Control Model:

Let there be n -deteriorating items under a production inventory system. Here, though the system is under a single management, the production-inventory process for each item is considered separately to minimize the corresponding cost. The items are stored together in a single go-down of finite dimension. These are produced at a variable rate

$U_i(t)$ and deteriorate at a constant rate, α_i . Demand of the items are time dependent and the stock level at time, t decreases due to deterioration and consumption. Shortages are not allowed.

The differential equation for i -th item representing above system during a fixed time-horizon, T is

$$\dot{X}_i(t) = U_i(t) - D_i(t) - \alpha_i X_i(t)$$

$$0 \leq U_i(t) \leq u_i, D_i(t) \geq 0, 0 \leq t \leq T.$$

Assuming the warehouse of finite capacity, minimization of total costs consisting of holding and production costs for each item leads to

$$\text{Minimize } J_i = \int_0^T (h_i X_i(t) + C_{ui} U_i(t)) dt \text{ -----(1)}$$

$$\text{subject to } \dot{X}_i(t) = U_i(t) - D_i(t) - \alpha_i X_i(t) \text{-----(2)}$$

$$\text{with space constraint, } \sum_{i=1}^n a_i X_i(t) \leq M \text{-----(3)}$$

In order to derive the approximate target level of the total cost for each item, the coupling constraint (3) for the above multi-objective problem is decoupled on the assumption that the items share the warehouse space equally i.e we optimize (1) subject

$$\text{to (2) and } a_i X_i(t) \leq \frac{M}{n}, i = 1, 2, \dots, n.$$

The corresponding Hamiltonian function is

$$H_i(X, U, t) = -(h_i X_i(t) + C_u U_i(t) + p_i(t) (U_i(t) - D_i(t) - \alpha_i X_i(t)))$$

and the Lagrangian function

$$L_i(X, U, t, \lambda) = H_i(X, U, t) + \lambda_i (a_i X_i(t) - \frac{M}{n})$$

where $\lambda_i \geq 0$ is the Lagrange multiplier.

Then, the Kuhn-Tucker condition is

$$\lambda_i (a_i X_i(t) - \frac{M}{n}) = 0. \text{-----(4)}$$

The corresponding adjoint function $p_i(t)$ is given by first order differential equation,

$$\dot{p}_i(t) = -\frac{\partial L_i}{\partial X_i(t)}$$

$$\dot{p}_i(t) = h_i + \alpha_i p_i(t) - \lambda_i a_i.$$

Following the maximum principle, the Hamiltonian is maximized at every point of time with respect to admissible controllable production function $U_i(t)$. This leads to the relation,

$$\frac{\partial H_i}{\partial U_i(t)} = -C_{\dot{u}} + p_i(t)$$

From physical consideration, $\frac{\partial H_i}{\partial U_i(t)} \leq 0$, otherwise, $H_i(X, U, t)$ increases with $U_i(t)$ and hence the system becomes uncontrollable.

Therefore, for a bang-bang controllable production system,

$$U_i(t) = u_i, \quad \text{if } p_i(t) - C_{\dot{u}} \geq 0 \text{-----(5)}$$

$$= 0 \quad \text{if } p_i(t) - C_{\dot{u}} \leq 0 \text{-----(6)}$$

For this problem, let the demand function as

$$D_i(t) = d_{i1} + d_{i2}t \text{-----(7)}$$

Using the control variable $U_i(t)$ and solving the state equation, we find the minimum value J_i^* , $i = 1, 2, \dots, n$ of the above system.

Here we examine the method where the ideal objective vector is used as a reference point. An objective vector minimizing each of the objective functions is called an ideal objective vector. In this case, the problem to be solved is

$$\text{Minimize } J = \sum_{i=1}^n \int_0^T |h_i X_i(t) + C_{\dot{u}} U_i(t) - \frac{J_i^*}{T}|^p dt$$

$$\text{subject to } \dot{X}_i(t) = U_i(t) - D_i(t) - \alpha_i X_i(t)$$

$$\text{with space constraint, } \sum_{i=1}^n a_i X_i(t) \leq M$$

$$\text{and } 0 \leq U_i(t) \leq u_i, D_i(t) \geq 0, 0 \leq t \leq T.$$

Pessimistic reference points must be avoided since the method cannot find solutions better than the reference point. An usual value of p is 2. This method is also sometimes called as compromise Programming (cf. Miettinen[11], Yu[12], Zeleny[13]).

The corresponding Hamiltonian function is

$$H(X, U, t) = \sum_{i=1}^n \left[-(h_i X_i(t) + C_{\dot{u}} U_i(t) - \frac{J_i^*}{T})^2 + p_i(t) \right.$$

$$\left. (U_i(t) - D_i(t) - \alpha_i X_i(t)) \right].$$

and the Lagrangian function

$$L(X, U, t, \lambda) = H(X, U, t) + \lambda \left(\sum_{i=1}^n a_i X_i(t) - M \right) \text{-----(8)}$$

where $\lambda \geq 0$ is the Lagrange multiplier.

Then, the Kuhn-Tucker condition is

$$\lambda \left(\sum_{i=1}^n a_i X_i(t) - M \right) = 0 \text{-----(9)}$$

The corresponding adjoint function $p_i(t)$ is given by first order differential equation,

$$\dot{p}_i(t) = -\frac{\partial L}{\partial X_i(t)}$$

$$\dot{p}_i(t) = 2(h_i X_i(t) + C_{\dot{u}} U_i(t) - \frac{J_i^*}{T})h_i + \alpha_i p_i(t) - \lambda_i a_i \text{-----(10)}$$

with $p_i(0) = p_{i0}$.

Following the maximum principle, the Hamiltonian is maximized at every point of time with respect to admissible controllable production function $U_i(t)$. This leads to the relation,

$$\frac{\partial H}{\partial U_i(t)} = -2(h_i X_i(t) + C_{\dot{u}} U_i(t) - \frac{J_i^*}{T})C_{\dot{u}} + p_i(t)$$

From physical consideration and bounded production system,

$$U_i(t) = 0, \quad \text{if } p_i(t) - 2h_i X_i(t)C_{\dot{u}} + \frac{2J_i^*}{T}C_{\dot{u}} \leq 0 \text{-----(11)}$$

$$= \frac{p_i(t) - 2h_i C_{\dot{u}} X_i(t) + \frac{2J_i^* C_{\dot{u}}}{T}}{2C_{\dot{u}}^2},$$

$$\text{if } 0 < p_i(t) - 2(h_i X_i(t) + \frac{J_i^*}{T})C_{\dot{u}} \leq 2C_{\dot{u}}^2 u_i \text{-----(12)}$$

$$= u_i, \quad \text{if } p_i(t) - 2h_i X_i(t)C_{\dot{u}} + \frac{2J_i^*}{T}C_{\dot{u}} > 2C_{\dot{u}}^2 u_i \text{-----(13)}$$

From equation (10), we get,

$$\dot{p}_i(t) = \left(\frac{h_i}{C_{\dot{u}}} + \alpha_i\right)p_i(t) - \lambda_i a_i, \quad 0 < p_i(t) - 2(h_i X_i(t) + \frac{J_i^*}{T})C_{\dot{u}} \leq 2C_{\dot{u}}^2 u_i$$

Therefore in this case,
$$p_i(t) = p_i(0)e^{\left(\frac{h_i}{C_{\dot{u}}} + \alpha_i\right)t} - \lambda a_i \frac{e^{\left(\frac{h_i}{C_{\dot{u}}} + \alpha_i\right)t} - 1}{\left(\frac{h_i}{C_{\dot{u}}} + \alpha_i\right)}$$

From equation (12)-(13),

$$\dot{X}_i(t) = -D_i(t) - \alpha_i X_i(t), \quad p_i(t) - 2h_i X_i(t)C_{\dot{u}} + \frac{2J_i^*}{T}C_{\dot{u}} \leq 0$$

$$\begin{aligned}
&= -\left(\frac{h_i}{C_{\dot{u}}} + \alpha_i\right)X_i(t) + \frac{p_i(t)}{2C_{\dot{u}}^2} + \frac{2J_i^*}{\mathcal{T}_{\dot{u}}} - D_i(t) \\
&0 < p_i(t) - 2\left(h_i X_i(t) + \frac{J_i^*}{T}\right)C_{\dot{u}} \leq 2C_{\dot{u}}^2 u_i \\
&= u_i - D_i(t) - \alpha_i X_i(t) \quad p_i(t) - 2h_i X_i(t)C_{\dot{u}} + \frac{2J_i^*}{T}C_{\dot{u}} > 2C_{\dot{u}}^2 u_i
\end{aligned}$$

Let us consider in $t_{i1} \leq t \leq T$, $p_i(t)$ and $X_i(t)$ satisfy the inequality

$$0 < p_i(t) - 2\left(h_i X_i(t) + \frac{J_i^*}{T}\right)C_{\dot{u}} \leq 2C_{\dot{u}}^2 u_i, \text{ then,}$$

$$\begin{aligned}
X_i(t) &= X_i(t_{i1})e^{-\beta_i(t-t_{i1})} + \frac{1}{2C_{\dot{u}}^2} (p_i(0) \frac{e^{\beta_i t} - e^{-\beta_i(t-2t_{i1})}}{(2\beta_i)} - \lambda a_i \\
&\frac{e^{\beta_i t} + 2e^{-\beta_i(t-2t_{i1})} - e^{-\beta_i(t-2t_{i1})-2}}{(2\beta_i^2)} + \frac{J_i^*}{\mathcal{T}_{\dot{u}}} \frac{1 - e^{-\beta_i(t-2t_{i1})}}{\beta_i}) \\
&- d_{i1} \frac{1 - e^{-\beta_i(t-t_{i1})}}{\beta_i} - d_{i2} \left(\frac{t - t_{i1} e^{-\beta_i(t-2t_{i1})}}{\beta_i} - \frac{1 - e^{-\beta_i(t-t_{i1})}}{\beta_i^2} \right) \quad \text{where}
\end{aligned}$$

$$\beta_i = \frac{h_i}{C_{\dot{u}}} + \alpha_i \text{-----(14)}$$

Here, the optimum value of λ is obtained by trial and error method satisfying the resource(i.e space) constraint (equation(9)).

Numerical Illustration:

To illustrate the above inventory model numerically, an inventory system of two items with a storage house of maximum space of 100 sq mt is considered. The other relevant input data are:

Table-1
Input data

i	h_i (in \$)	C_{ii} (in \$)	$X_i(t)$	α_i	p_i	u_i	a_i (sq. mt.)
1	1	2	25	0.04	1.0	20	1.2
2	1.1	2.2	30	0.05	1.2	22	1.3

The different scenarios are built-up for different values of demand ($d_{i1}+d_{i2}t$). The initial values for demand under different scenarios are:

Table-2
Input demand under scenario-1

i	d_{i1}	d_{i2}
1	1.0	2.0
2	1.1	2.2

Table-3
Input demand under scenario-2

i	d_{i1}	d_{i2}
1	2.5	-0.4
2	3.3	-0.8

Table-4
Input demand under scenario-3

i	d_{i1}	d_{i2}
1	16	0
2	9	0

For these input data, $X_i(t)$, $U_i(t)$ and $D_i(t)$ are evaluated using (2), (5)-(6) and (7) for single objective and (14), (11)-(13) and (7) for multi-objective respectively for

different values of t.

The values of these functions for scenarios-1 are presented against different values of t in Tables -5 and -6 for single objective models respectively and multi-objective and also by trial and error method optimum values, the evaluated of Langrange's multipliers are ($\lambda_1 = 0.2$, $\lambda_2 = 0.5$, $\lambda = 5.5$). Similar, for scenarios-2 and -3, the results presented in Tables -(7 and 8) and -(9 and 10) and the corresponding Langrange's multipliers are

($\lambda_1 = 0.8$, $\lambda_2 = 0.2$, $\lambda = 5.6$) and ($\lambda_1 = 0 = \lambda_2 = \lambda$).

Table-5

Values of $X_i(t)$ $U_i(t)$ and $D_i(t)$ for single-objective under scenario-1

t	0	1.01	1.22	2	3
$X_i(t)$	25	19.30	18.08	28.09	41.65
	30	6.53	9.01	20.80	38.41
$U_i(t)$	0	0	20	20	20
	0	25	25	25	25
$D_i(t)$	4.5	5.0	5.11	5.5	6.0
	3.3	3.5	3.544	3.7	3.9

Table-6

Values of $X_i(t)$ $U_i(t)$ and $D_i(t)$ for multi- objective under scenario-1

t	0	1.0	2	3
$X_i(t)$	25	29.98	31.21	29.37
	30	41.91	47.37	47.94
$U_i(t)$	12.82	9.12	6.42	3.76
	21.12	14.04	9.48	5.94
$D_i(t)$	4.5	5.0	5.5	6.0
	3.3	3.5	3.7	3.9

Table-7Values of $X_i(t)$, $U_i(t)$ and $D_i(t)$ for single objective under scenario-2

t	0	1.16	1.32	2	3
$X_i(t)$	25	21.29	12.57	24.42	41.60
	30	5.21	7.52	15.92	38.39
$U_i(t)$	0	0	20	20	20
	0	25	25	25	25
$D_i(t)$	2.5	2.036	1.972	1.7	1.3
	3.3	2.372	2.244	1.6	0.75

Table-8Values of $X_i(t)$, $U_i(t)$ and $D_i(t)$ for multi- objective under scenario-2

t	0	1.0	2	3
$X_i(t)$	25	29.02	30.59	31.34
	30	41.25	47.21	47.99
$U_i(t)$	9.0	5.95	3.4	1.01
	19.49	12.94	8.36	4.56
$D_i(t)$	2.5	2.1	1.7	1.3
	3.3	2.45	1.6	0.75

Table-9Values of $X_i(t)$, $U_i(t)$ and $D_i(t)$ for single objective under scenario-3

t	0	0.84	1.32	2	3
$X_i(t)$	25	10.89	9.32	13.08	16.49
	30	4.42	4.79	14.28	27.13

$U_i(t)$	0	0	20	20	20
	0	25	25	25	25
$D_i(t)$	16	16	16	16	16
	9	9	9	9	9

Table-10

Values of $X_i(t)$, $U_i(t)$ and $D_i(t)$ for multi- objective under scenario-3

t	0	1.0	2	3
$X_i(t)$	25	18.50	14.74	12.73
	30	37.32	41.67	44.37
$U_i(t)$	8.50	11.84	13.86	15.13
	19.94	16.37	14.36	13.28
$D_i(t)$	16	1	16	1
	9	9	9	9

For the above values of $X_i(t)$, $U_i(t)$ and $D_i(t)$ in different scenarios, these functions can be plotted for different values of t in (0,T). Here, $X_1(t)$, $U_1(t)$ and $D_1(t)$ are depicted in figs-1.1, 1.2, 2.1, 2.2 and 3.1, 3.2 respectively. The curves for $X_2(t)$, $U_2(t)$ and $D_2(t)$ are of similar nature.

The operating costs under scenario-1 are $J_1 = 151.7$ \$, $J_2 = 237.5$ \$ (total cost = 388.74\$) for single-objective and $J = 357.3$ \$ for multi-objectives. Similarly the operating costs under scenarios-2 and -3 are $J_1 = 128.7$ \$, $J_2 = 226.5$ \$ (total cost = 355.07\$) and $J_1 = 125.6$ \$, $J_2 = 229.9$ \$ (total cost = 354.95\$) for single-objectives and $J = 330.3$ \$, $J = 358.9$ \$ or multi-objectives.

4. Discussion:

It is interesting to note that when the deteriorating multi-items inventory-production model is formulated as a single-objective one, the optimal control system is of Bang-Bang type (cf. figs 1.1, 2.1, 3.1). But for multi-objective model formulation, it is under

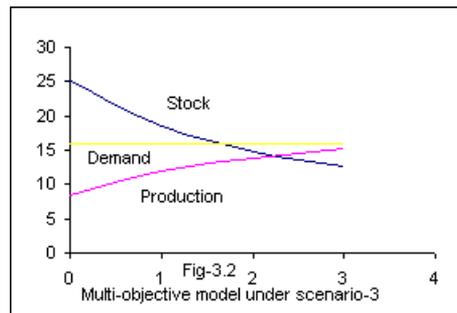
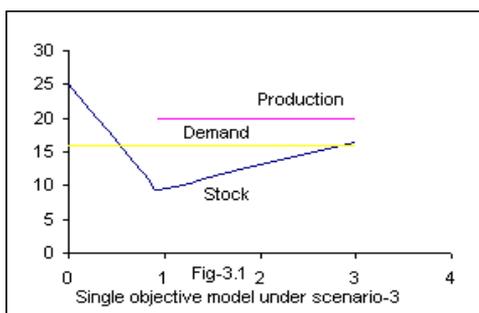
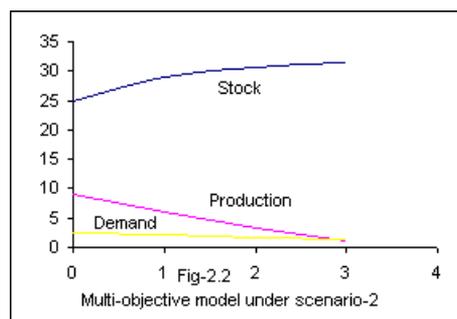
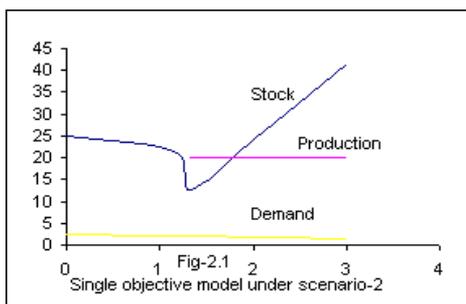
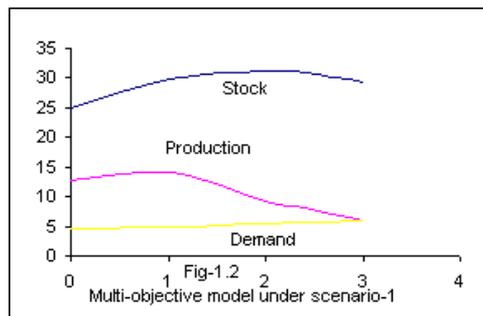
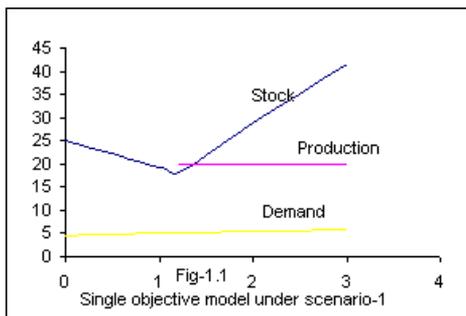
continuous production control (cf. figs 1.2, 2.2, 3.2). This is because in single objective formulation, the production control is of linear form whereas in the multi-objective one, it is of non-linear form with $p=2$. It is also noted that the behaviour of stock level in these two types of formulations are quite different. But in spite of these differences, the total operating costs under two types of formulations are almost same.

5. Conclusion:

This paper has proposed, a optimal production-inventory policy for multi-objective and deteriorating multi-item production inventory system with space capacity constraint and time dependent demand. A multi-objective and multi-item dynamic system with a resource constraint has been solved for the first time via optimal control theory. The formulation and analysis presented here can be extended to other production-inventory problems with different types of demand, deterioration, price discount, shortage cost, etc.

6. References:

1. Harris, F., Operations and cost (*Factory management series*), Chicago, A.W. Shaw co., 1915.
2. Hadley, G and Whitin T.M., *Analysis of Inventory system*, Prentice-Hall, Englewood, cliffs.
3. Naddor, E., *Inventory systems*, 1966, Wiley, New York
4. Hu, J.Q. and Loulon, R., 1995, Multi-product production / inventory control under random demands. *IEEE Transaction on Automatic control*, 40, 350-355.
5. Kirk, D.E., 1970, Optimal control Theory. *An Introduction* (New Jersey: Prentice Hall).
6. Hu, J.Q. and Dong, X., 1995, optimal control for systems with deterministic production cycles, *IEEE Transaction on Automatic control*, 40, 782-787.
7. Aliyu, M.D.S. and Andhani, A.A., Multi-item-multi-plant inventory control of production systems with shortages/backorders, *Int. Journal of systems Science*, 1999, volume 30, number 5, pages 533-539.
8. Bhunia, A. K. and Maiti, M., A deterministic inventory replenishment problem for deteriorating items with time dependent demand and shortages for the finite time horizon, *OPSEARCH*, India, vol. 34, No. 1, 51-61, 1997.
9. Mandal, M. and Maiti, M. (1999), Inventory of damageable items variable replenishment rate, stock-dependent demand, and some units in hand *Applied Mathematical Modelling*, 23, 799-807.
10. Giri, B. C. and Chaudhuri, K. S. (1998), Deterministic models of permishable inventory with stock-dependent demand rate and nonlinear holding cost, *European Journal of Operational Research*, 105, 467-474.
11. Miettiner, K.M., (1999), Non-linear Multi-objective Optimization, Kluwer, s International Series.
12. Yu, P.L., (1973), A Class of Solutions for Group Decision Problems, *Management Science*, 19, no. 8, 936-946.
13. Zeleny, M., (1973) Compromise Programming, Multiple Criteria Decision Making, Edited by J.L. Cochrane, M. Zeleny, University of South Carolina Press, Columbia, South Carolina, 262-301.



Effectiveness of Amine Functional Polymers as Curing and Toughening Agents for Epoxy Resin

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Abstract

With the development of polymer science and technology, people started using polymer as a material in various applications. This can be attributed to the obvious advantages of polymers like light weight, easy processability, high specific strength and potentiality for wide modification. The broad interest in epoxy resins originates from the extremely wide variety of chemical reactions. Unfortunately, these highly crosslinked networks are inherently brittle and consequently have limited utility in applications. That is why toughening of polymer has been an immense interest throughout the world and is more challenging to the expertise of polymer chemist.

Keywords: Epoxy Resin; Curing; Toughening; Amine Functional Polymers

1. Introduction

In epoxy resin technology, conversion from a liquid or friable brittle solid into a tough cross linked polymer is called curing or hardening, and is achieved by the addition of curing agent (hardener). The curing agents fall broadly into two types, catalytic and polyfunctional and cross-linking between the resin molecules is achieved through the epoxide or hydroxyl groups of the resin. The catalytic curing agents serve as initiators for resin homo polymerization, whereas the polyfunctional curing agents are used in near stoichiometric amounts and function as reactants or co-monomers in the polymerization, leading mainly to the formation of a three dimensional network composed of resin molecules cross-linked via the curing agents. In most of the curing reactions the actual

mechanism is ionic in nature; both anionic and cationic polymerization can occur, depending upon the curing agent concerned.

Cure normally occurs without the formation of by products. The curing reactions are exothermic and the rates of the reaction are increased by increases in temperature. Klute and Viehmann [1] measure the heat of polymerization of liquid epoxide resins and found value of 22 kcal/mole epoxide when a tertiary amine was used as a curing agent and 25 kcal/mole epoxide when a primary amine was employed. Rates of reaction and activation energies have also been measured for certain polymerizing systems. The heat formed by the exothermic reaction can lead to a considerable rise in temperature of the system, known as “exotherm”, and the actual levels reached depend only upon the reactivity of the resin and curing agent but also upon the temperature of the reactants and their surroundings, i.e. the rate at which polymerization is occurring and the rate at which the heat evolved is being dissipated to the surroundings.

The curing of epoxy resin is based on the reaction of the epoxide molecules themselves or the reaction between the epoxide group and other kinds of reactive molecules with or without the help of a catalyst. The former is homo polymerization, and the latter is an addition reaction, but both result in coupling as well as cross-linking. The reaction mechanism that occurs during the cure of epoxy resin has no immediate connection with this classification. Although, in a broad sense, epoxy curing agents are classed as catalytic, many of these cure by polyaddition reactions. Polyaddition is most commonly used reaction for the cured of epoxy resin. The most widely used curing agents, based on such active hydrogen compounds as polyamines, polyacids, polymercaptans, and polyphenols, undergo the additions via the active hydrogen and the terminal carbon of the epoxy group, with the subsequent conversion of the epoxide into a hydroxyl group. Although these reactions are generally based on one active hydrogen in the curing agent per epoxide group, practical systems are not always based on this stoichiometry because of homo polymerization of the epoxide or other side reactions that cannot be avoided and are sometimes desired. In cures with anhydrides the stoichiometry is one anhydride per epoxide group. Excellent reviews on this subject were presented by Potter [2], May and Tanaka [3], and Lee and Neville [4].

In the fifty years of epoxide resin technology, a vast number of compounds have been screened for their suitability as curing agents. Many compounds used in the early years of the technology have now been superseded by more sophisticated materials, though some still retain their popularity and even occasionally enhance it. The choice of curing agent to be used with an epoxide resin will depend upon:

The handling characteristics required or tolerable in the uncured system, such as viscosity at working temperature, pot life, exotherm, and toxicity, (b) the cured and

post-cured time and temperature requirements, (c) the properties (physical, mechanical, electrical, and chemical) required of the cured system and (d) the cost of curing agent. The correct choice of curing agent can therefore be as important as the choice of resin itself, both playing a part of determining the excellent and nature of the intermolecular cross-linking. The curing agents are categorized into two general classes, active hydrogen compounds and ionic catalyst. The curing agents having active hydrogen are (i) aliphatic polyamines and their derivative (ii) modified aliphatic polyamines (iii) aromatic amines (iv) polyphenols and their derivative (v) acid anhydrides. Ionic catalysts are divided into cationic and anionic catalysts.

Epoxy resins are a class of versatile polymeric materials characterized by the presence of two or more oxirane or epoxy group, which is a three membered oxide ring. The simplest compound in which it is found is ethylene oxide. Like other thermosets they also form network on curing with a variety of curing agents [5-10] like amines, anhydrides, thiols, polyamides etc. It is in this cured form, when all the epoxide groups have reacted, that resins are almost always used; in the uncured non-crosslinked state they are of limited utility. The most important group of resins comprises the glycidyl ethers of dihydroxy compounds and most of them are made by interaction of epichlorohydrin (ECH) and diphenylolpropane or commonly known as Bisphenol-A (BPA). Epoxies are one of important thermosetting materials for high performance adhesives and composites matrix applications. These highly cross-linked networks combine good thermal and mechanical properties with outstanding adhesive properties. However, their inherent brittle behavior limits them for wide applications requiring high impact properties and high fracture strengths. Initial attempts to improve ductility or impact strength for epoxy thermoset systems employed various levels of “reactive” or “nonreactive” plasticizers based on long chain epoxidized glycols and dimer acids [9]. However, the use of most of these modifiers reduced thermal stability and strengths. Traditional toughness modifiers such as carboxyl terminated butadiene acrylonitrile copolymer rubbers (CTBN) have been widely used to improve toughness since the frontier work by Sultan and McGarry [11, 12]. However, such improvements were achieved at the expense of high temperature performance.

In the present endeavor, the syntheses, characterization of low and high molecular weight amine functional polymers and their curing and toughening studies with diglycidyl ether of bisphenol A (DGEBA) (LY 556) resin have been studied along with evaluation of mechanical and thermal properties of that modified epoxy networks. The results show that the low and high molecular weight amine functional polymers can be successfully used as curing and toughening agents respectively for DGEBA resin without deterioration of useful thermo mechanical properties.

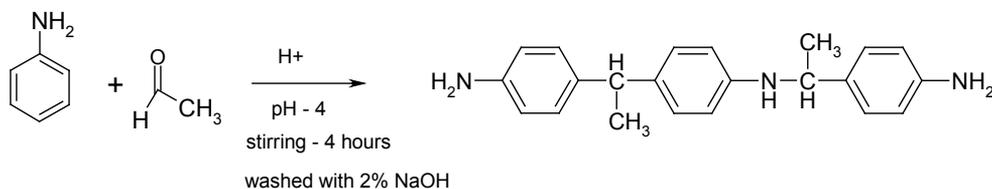
2. Experimental Section

2.1 Synthesis and Characterization of amine functional polymers

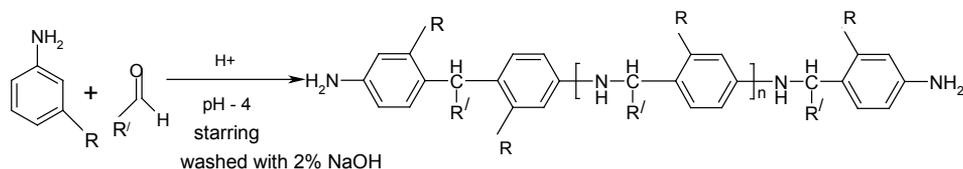
Low molecular weight amine functional polymers i. e. amine functional aniline

acetaldehyde condensate (AFAAC-L) and amine functional chloroaniline acetaldehyde condensate (AFCAC-L) were synthesized from the reaction of aniline and chloroaniline with acetaldehyde in acidic medium differently taking 1:0.8 mole ratio of amine and aldehyde. Aromatic amine (1.64 moles) was first mixed with sufficient amount of HCl to reach pH 4 of the medium. Then the mixture was taken into a three necked flask fitted with a stirrer and allowed to stir without heating. Now the acetaldehyde (1.31 moles) was added to it at a fixed interval of 10 minutes over a period of 1 hour and the stirring was continuing for 6 hours. Then the reaction was stopped and the red color liquid product was washed with 2% NaOH first and then with water till the mixture became neutral. Finally the product was dried in an oven at 90°C. The yield of the product was ~ 80%. The reaction details are shown in Scheme 1.

High molecular weight amine functional polymers i.e. amine functional aniline acetaldehyde condensate (AFAAC-H) and amine functional chloroaniline acetaldehyde condensate (AFCAC-H) had been synthesized by the reaction of aniline and chloroaniline with acetaldehyde differently taking 1:1 mole ratio of amine and aldehyde. Amine (2.197 moles) was first of all mixed with sufficient amount of HCl to reach pH 4 of the medium. Then the pale yellow colored solution was taken into a three necked flask fitted with a stirrer and was stirred without heating. Now the required amount of acetaldehyde (2.197 moles) was added to it at a fixed interval of 10 minutes over a period of 1 hour and the stirring was continued for 10 hours. Then the stirring was stopped and the product was washed with 2% NaOH first and then with water till the mixture became neutral. Finally the red colored liquid product was dried in an oven at 90°C. The yield of the product was 90%. The reaction details are shown in Scheme 2.



Scheme 1 Synthesis of AFAAC-L (R= H, R'= CH₃) and AFCAC-L (R= Cl, R'= CH₃)



Scheme 2 Synthesis of AFAAC-H (R= H, R'= CH₃) and AFCAC-H (R= Cl, R'= CH₃)

Each of the oligomers was characterized by FT-IR and ¹H-NMR spectroscopic analyses, viscosity measurements, elemental analysis, determination of mole of primary and secondary amine per gram of the each oligomer by potentiometric titration and molecular weight determination.

2.2 Formation of cured epoxy networks

Equimolecular amount of i.e. 35 phr (parts per hundred part of epoxy resin) of AFAAC-L and 45 phr of AFCAC-L were mixed separately with epoxy resin by stirring at room temperature and poured into aluminum mold. Details of various formulations are given in Table 1. All the formulation was kept at the room temperature for two days. Then all formulations was cured at 100°C for 2 hours and post cured for 2 hours at 150°C.

Table 1 Details of various formulations for curing of epoxy resin

Formulation	Resin system	compositions
A	DGEBA + AFAAC-L	100:35
B	DGEBA + AFCAC-L	100:45

2.3 Modification of epoxy resin and preparation of epoxy networks by AFAAC-H and AFCAC-H

To enhance the fracture strengths, modifications of epoxy resin by AFAAC-H and AFCAC-H were done before curing by two processes. In one step process, liquid oligomers were mixed with epoxy resin separately by stirring at room temperature and the mixture was kept for 2 hours at room temperature. In the two-step process, first the liquid oligomers were mixed with epoxy resin separately by stirring at room temperature. This formulation was heated at 80°C for one hour and then cooled slowly to room temperature. Various formulations made by using different concentrations of each thermoplastic oligomer are given in Table 2. All the compositions were found to be homogeneous in nature and cured with required amount of triethelene tetramine (HY 951) hardener at room temperature for 24 hours and post-cured for two hours at 150°C till no exotherm was noted in DSC run.

Table 2 Compositions of unmodified, AFAAC-H and AFCAC-H modified epoxy networks

Sample	Composition		
	LY 556(parts)	HY 951(phr)	Modifier (phr)
A-0	100	13	Modifier (0 phr)
H-1	100	13	AFAAC-H (5 phr)
H-2	100	13	AFAAC-H (7.5 phr)
H-3	100	13	AFAAC-H (10 phr)
H-4	100	13	AFAAC-H (12.5phr)
H-5	100	13	AFAAC-H (15 phr)

T-1	100	13	AFCAC-H (5 phr)
T -2	100	13	AFCAC-H (7.5 phr)
T -3	100	13	AFCAC-H (10 phr)
T -4	100	13	AFCAC-H (12.5phr)
T -5	100	13	AFCAC-H (15 phr)

3. Results and Discussions

3.1 Differential scanning calorimetry analysis for curing reaction

The curing behavior was followed by DSC. Equimolecular mixture of DGEBA and each oligomer was mixed separately and the clear viscous solution was subjected to DSC analysis (Table 1). Figure 1 & 2 show the residual exotherms of DSC scans of AFAAC-L (A) and AFCAC-L (B) formulation pertaining at four heating rates (a-5, b-10, c-15, and d-20°C/min) indicating the occurrence of curing reaction. Reheating after cooling for 10°C/min (Fig. 3) shows no residual exotherm indicating glass transition (T_g) at high temperature region (134-155°C) [13-21] i.e. Figure 3 shows the completion of curing reaction of each formulation.

The conversion profiles of each formulation calculated from heat of exotherm values with a fixed interval of time [22] are shown in Figure 4 and 5. The figures clearly indicate that the degree of conversion is less than 100%. From these figures the half-value period ($t_{1/2}$) for all curing reaction at four heating rate has also been evaluated and order of the reaction calculated by half-value period method indicates that all the curing reactions are first order. The initiation temperature (T_i), peak exothermic temperature (T_{max}), completion temperature (T_f), heat of cure (ΔH) and rate constant calculated from $t_{1/2}$ at four heating rates for each formulation are summarized in Table 3. The kinetic parameters i.e. energy of activation (E_a) and frequency factor ($\ln A$) were calculated by employing the Ozawa and Kissinger equations [23, 24]

$$E_a = -R \Delta \ln \beta / 1.052 \Delta (1/T_{max})$$

$$-\ln [\beta / T_{max}^2] = E_a / RT_{max} - \ln [AR/E_a]$$

Where E_a is the activation energy, R is the gas constant, β is the heating rate, $\ln A$ is the frequency factor, and T_{max} peak exotherm temperature of the corresponding β . These were obtained from a variable peak exotherm of epoxy formulation. The E_a from the Kissinger equation was calculated from the slope of the graph of $-\ln [\beta / T_{max}^2]$ versus $1/T_{max}$ and fitting to a straight line. The graph between $-\ln [\beta / T_{max}^2]$ and $1/T_{max}$ for AFAAC-L (A) and AFCAC-L (B) are shown in Figure 6 & 7 respectively. Kinetic parameters calculated from Kissinger equation for each formulation were summarized in Table 4.

Table 3 DSC results of formulations A, B, C and D

Formulation	Heating rate (° C/ min)	T_i (° C)	T_{max} (° C)	T_f (° C)	ΔH (J/g)	Rate constant (s^{-1})
-------------	----------------------------	----------------	--------------------	----------------	---------------------	----------------------------

A	5	100	195	280	527	4.10×10^{-4}
	10	120	212	280	498	8.38×10^{-4}
	15	130	229	300	469	1.21×10^{-3}
	20	135	240	300	416	1.66×10^{-3}
B	5	130	205	290	829	4.90×10^{-4}
	10	137	227	290	719	8.67×10^{-4}
	15	142	238	320	697	1.25×10^{-3}
	20	150	247	300	549	1.47×10^{-3}

Table 4 Kinetic parameters obtained from Ozawa and Kissinger equation for each formulation

Formulation	E_a (KJmol ⁻¹)	Ln A (min ⁻¹)
A	52.76	9.43
B	63.43	10.21

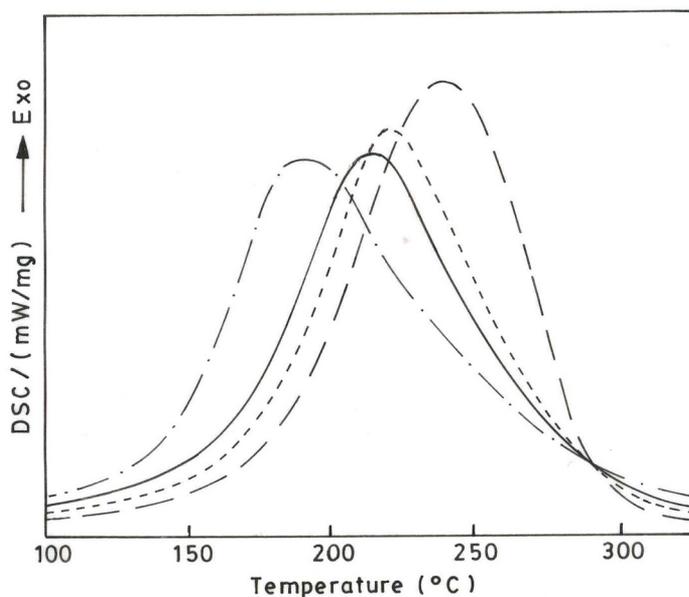


Figure 1 Curing exotherm of AFAAC-L formulation (A) at four heating rates (a) 5 (b) 10 (c) 15 (d) 20 °C/min

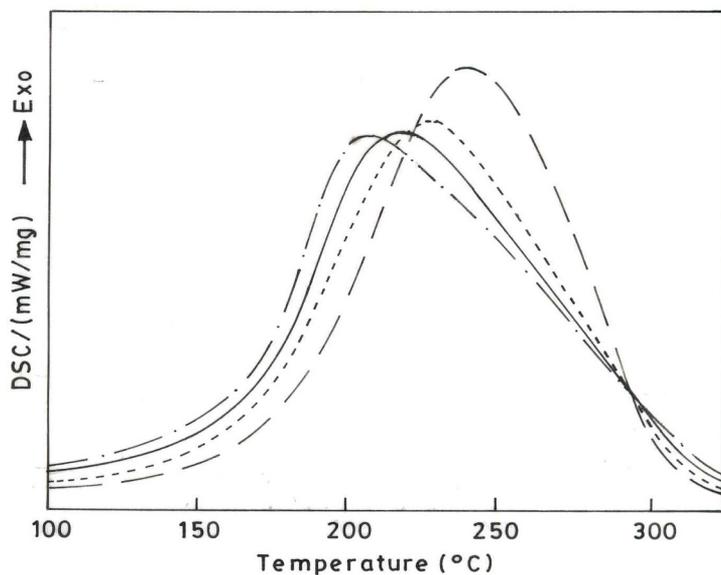


Figure 2 Curing exotherm of AFCAC-L formulation (B) at four heating rates (a) 5 (b) 10 (c) 15 (d) 20 °C/min

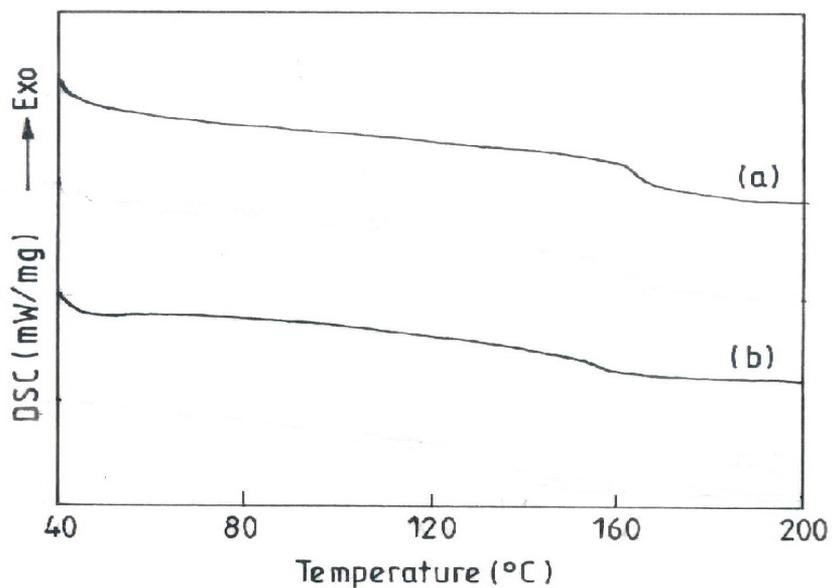


Figure 3 T_g curves of (a) AFAAC-L (A) and (b) AFCAC-L (B) formulations

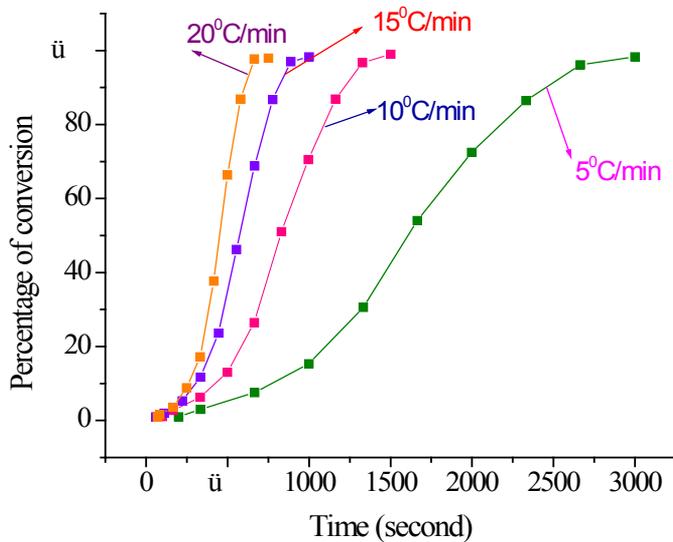


Figure 4 Percentage of conversion vs. time plot of AFAAC-L formulation (A)

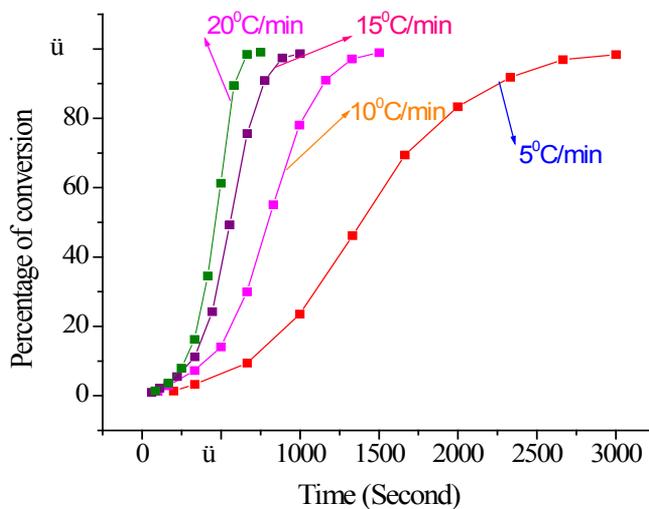


Figure 5 Percentage of conversion vs. time plot of AFCAC-L formulation (B)

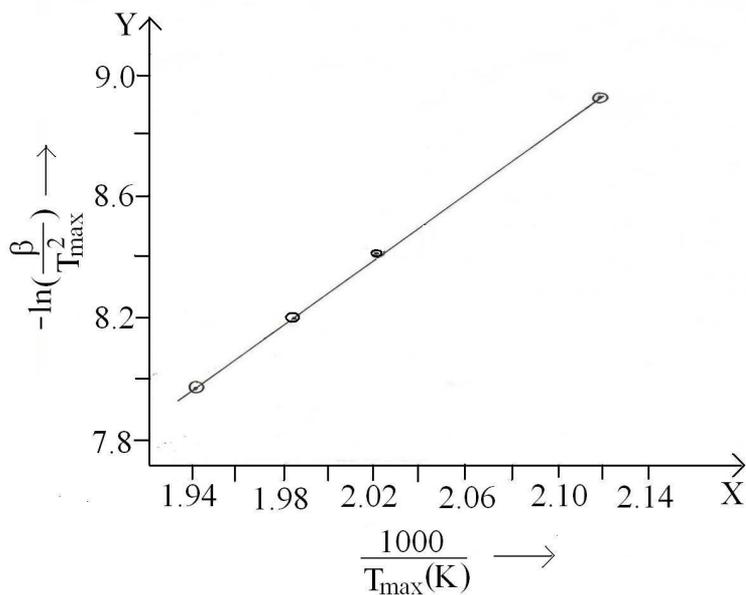


Figure 6 Graph of $-\ln [\beta/ T_{\max}^2]$ vs. $1000/T_{\max}$ (K) of AFAAC-L formulation (A)

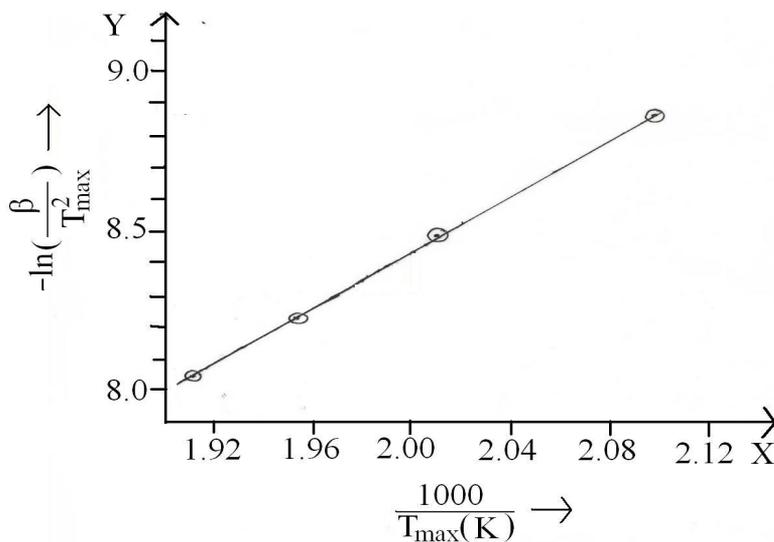


Figure 7 Graph of $-\ln [\beta/ T_{\max}^2]$ vs. $1000/T_{\max}$ (K) of AFCAC-L formulation (B)

3.2 Mechanical properties of cured epoxy

For complete understanding of the mechanical properties of cured epoxy (formulation A & B), impact, tensile and flexural tests were carried out. The results of impact, tensile and flexural strengths of formulation A and B have been shown in Table 5. The results show that the fracture strengths of the cured epoxy are not so high. The formulation A attains the higher impact, tensile and flexural strengths than other formulation B. The higher cross-linked value and effective chemical bonding with epoxy lead to higher mechanical properties for formulation A.

Table 5 Impact, Tensile and Flexural strengths for cured epoxy

Formulation	Impact strength (J/m ²)	Flexural strength (MPa)	Tensile strength (MPa)
A	330	80.33	21.76
B	270	62.46	12.31

3.3 Evaluation of AFAAC-H and AFCAC-H modified epoxy networks

To check the effectiveness of AFAAC-H and AFCAC-H in increasing the fracture strengths of cured epoxy, the modified networks containing different concentrations of AFAAC-H and AFCAC-H (Table 2) were evaluated for their impact, tensile and flexural properties. The modified networks were also evaluated with respect to their thermomechanical properties.

The effect of incorporation of each modifier on impact, tensile and flexural strengths of unmodified and modified networks is shown in Table 6. The results show that impact, tensile and flexural strengths are vastly improved than unmodified one and also than formulation A. The increase depends on concentration of the modifier. The maximum increase is obtained at 10 phr (parts per hundred parts of epoxy resin) of each liquid modifier and after that the strength decreases with increase in concentration. This is because after an optimum concentration the liquid modifier acts more as a flexibilizer rather than a toughening agent. The amine groups of liquid modifier are expected to participate in the curing reaction of epoxy. In the initial stage, the liquid modifier is miscible with the epoxy resin and produces a clear homogeneous solution. This good mixing promotes the chemical reaction and network formation. During the curing process, as the molecular weight increases, the component separates within the reaction medium to form a second dispersed phase (confirmed from SEM). This two-phase microstructure consisting of small thermoplastic modifier particles dispersed and bonded to the epoxy matrix results in higher toughness [25]. When the concentration becomes higher than 10 phr, the compatibility of modifier with the matrix is too great to form separate modifier phase i.e. the system becomes homogeneous, and toughness decreases. Hence both the

toughening and flexibility effects can be operative, resulting in maximum improvement in impact, tensile and flexural strengths.

It is also clear from the result that mechanical strengths in two-step process are more than the one step process. This was because in two-step process, the reaction between each modifier and epoxy was maximum i.e. almost completing due to high temperature rather than one step process.

Table 6 Impact, tensile and flexural strengths of unmodified and modified epoxy networks

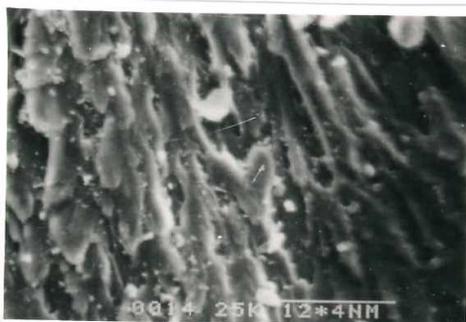
Sample	Impact strength (J/m ²)		Flexural strength (MPa)		Tensile strength (MPa)	
	One step	Two step	One step	Two step	One step	Two step
A-0	110	110	58.48	58.48	4.98	4.98
H-1	300	390	73.34	94.20	10.66	14.32
H-2	390	480	97.85	118.72	15.42	19.84
H-3	520	600	123.74	129.74	20.76	31.63
H-4	430	510	102.43	105.04	13.11	18.76
H-5	380	420	76.84	87.66	9.23	12.28
T-1	165	220	66.32	72.36	7.33	10.35
T-2	240	320	83.17	98.15	11.61	15.81
T-3	310	435	109.35	117.87	15.39	20.27
T-4	250	300	84.82	88.57	11.87	14.54
T-5	185	230	62.50	71.11	8.10	9.60

3.4 Scanning electron microscopy (SEM) analysis

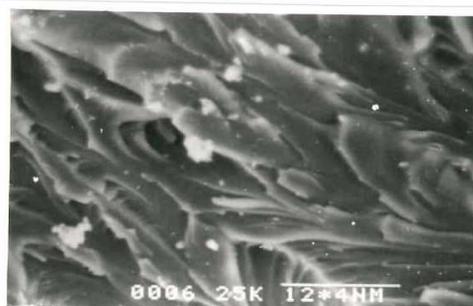
In order to correlate the molecular and morphological parameters with the fracture properties of the toughened networks, the microstructure of the fracture surfaces for AFAAC-H and AFCAC-H modified networks were analyzed by SEM. The SEM photographs for the toughened networks in two step process containing different concentration of AFAAC-H and in one step process containing 10 phr of AFAAC-H and the SEM photographs for the fracture surface of 10 phr of AFCAC-H modified epoxy network are shown in Figure 8. Beyond 10 phr, there is no improvement in impact, adhesive, tensile and flexural strengths rather a drop is observed. This may be explained considering the changes in morphology of the fractured surfaces of the cured epoxy resin by the addition of liquid modifier. The fracture surface of unmodified cured epoxy is homogeneous without any dispersed particles (Fig. 8A). For the modified formulations up to certain concentration of modifier (AFAAC-H), the morphology is a two-phase microstructure (Fig 8B & Fig 8C). At 10 phr, the morphology consists of relatively small polymer particles uniformly dispersed in the epoxy matrix (Fig 8C). This two-phase

microstructure is believed to increase the breaking strength by a crack terminating mechanism, and the fractured surface appears cavitated. On increasing the concentration of modifier above 10 phr, the second phase becomes indistinguishable from the matrix due to aggregation (Fig 8D). The polymer that does not phase-separate can lead to flexibilization of cured epoxy resin and hence can decrease the rigidity [26, 27]. In the SEM micrographs (Fig. 8E) of modified (10-phr of AFAAC-H) epoxy networks in one step process shows larger particle than the micrograph (Fig. 8C) in two step process as a result of aggregation. So the phase separation in one step process is not so much as in case of one step process. This explains the cause of lowering of mechanical strength in one step process.

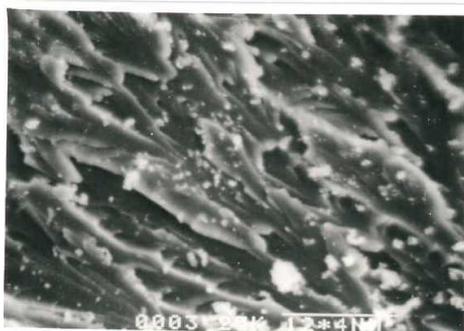
In comparison to the SEM photographs for the fracture surface of 10 phr of AFCAC-H and AFAAC-H modified epoxy network in two step process (Fig. 8H & 8C respectively), the former photograph shows the presence of big particles distributed haphazardly than last. The bigger particles cannot act efficiently in dissipating mechanical energy and would rather act as defect [28]. That is why the fracture properties of AFCAC-H are comparatively lower rather than AFAAC-H.



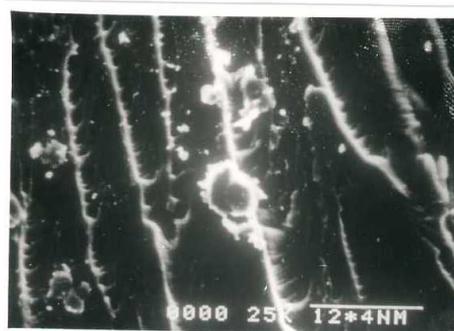
(A)



(B)



(C)



(D)

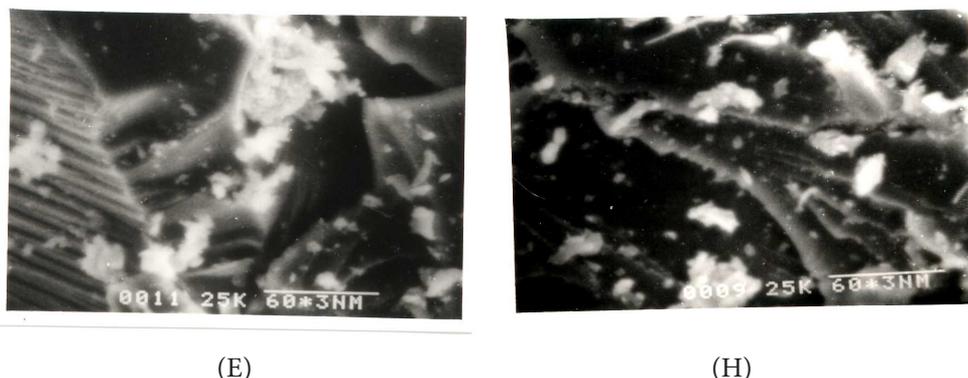


Figure 8 SEM micrographs for the fracture surfaces of (A) unmodified epoxy, (B) AFAAC-H modified epoxy in two step process (5-phr), (C) AFAAC-H modified epoxy in two step process (10-phr), (D) AFAAC-H modified epoxy in two step process (15-phr), (E) AFAAC-H modified epoxy in one step process (10-phr) and (H) AFCAC-H modified epoxy in two step process (10-phr).

3.5 Thermogravimetric analysis

The Thermogravimetric (TG) and differential thermogravimetric (DTG) analysis curves for unmodified (A-0), 10-phr of AFAAC-H and AFCAC-H modified epoxy networks (H-3 and T-3 respectively) are shown in Figure 9, 10 and 11 respectively. The relative thermal stability of the modified epoxy networks was assessed by noting the initial decomposition temperature (IDT), the temperature of the maximum rate of weight loss (T_{max}) and final decomposition temperature (FDT). The results of TG studies are summarized in Table 7. From the table it is shown that the initial decomposition temperatures of all the modified networks are greater than unmodified one i.e. they are more stable than unmodified one. It is also clear from the table that AFCAC-H modified epoxy network is comparatively more stable than others due to its higher molecular weight.

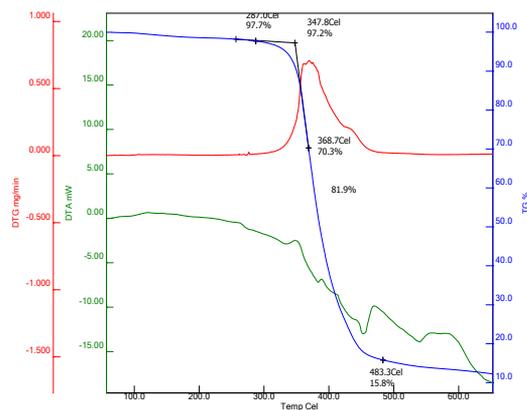
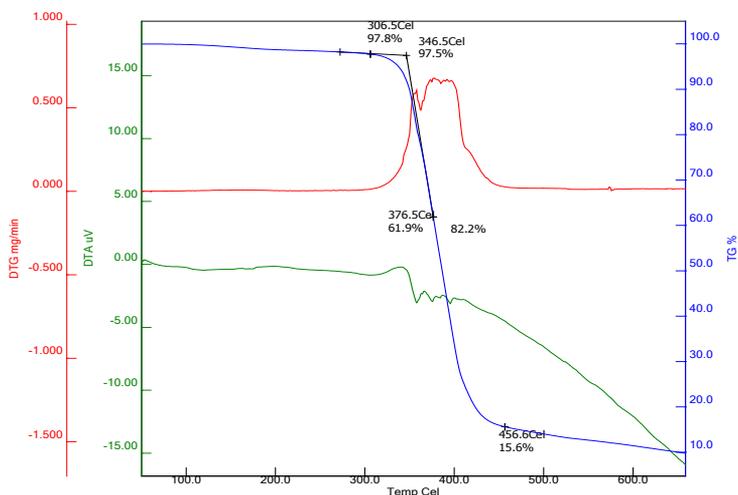
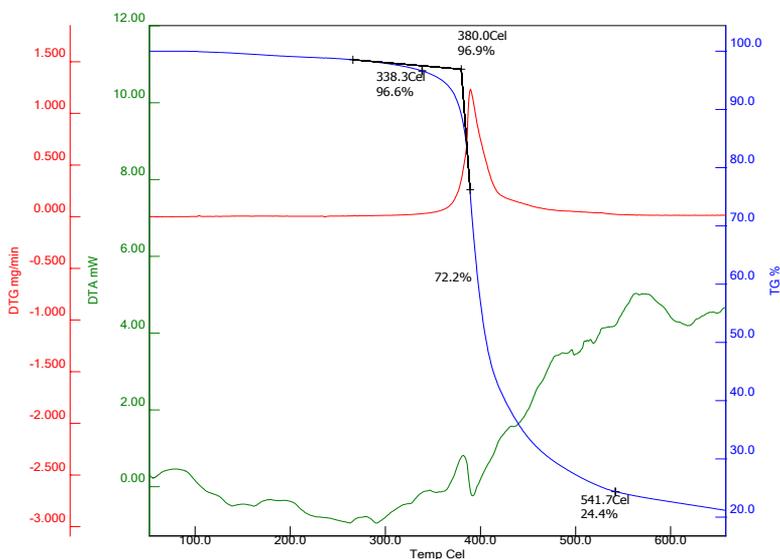


Figure 9 TG and DTG curves of unmodified epoxy network (A-0) under nitrogen flow (100ml/min) at a constant heating rate (10°C/min).

Table 7 TG results of A-0, H-3 and T-3 epoxy networks

Sample	IDT(°C)	T _{max} (°C)	FDT(°C)	Char portion %
A-0	287	347	483	15.8
H-3	307	346	457	15.6
T-3	338	380	541	24.4

**Figure 10** TG and DTG curves of AFAAC-H modified (H-3) epoxy network under nitrogen flow (100ml/min) at a constant heating rate (10°C/min).**Figure 11** TG and DTG curves of AFCAC-H modified (T-3) epoxy network under nitrogen flow (100ml/min) at a constant heating rate (10°C/min).

Conclusion

From the present study it can be concluded that the low molecular weight reactive oligomers are effective curing agents for DGEBA epoxy resin. DSC studies showed the completion of curing reactions indicating T_g of the cured matrix. Among the two curing agents, the AFAAC-L gives the maximum fracture properties for cured DGEBA epoxy network. It is also observed that improvement in fracture strengths of epoxy matrix occurs on toughening with high molecular weight reactive modifiers like AFAAC-H and AFCAC-H. The extent of toughening depends on the concentration of the modifier. Maximum improvement of fracture properties was obtained at 10 phr of liquid modifier concentration. The improvement was achieved with a slight sacrifice of glass transition temperature. Among the two toughening agents, AFAAC-H gives the maximum improvement in fracture properties. The SEM studies of the modified epoxy networks indicate phase separation. The modified networks having optimum properties, has always a two-phase microstructure. Agglomeration of modifier particles occurs at higher the optimum concentration and the microstructure becomes homogenous. This agglomeration acts as defects and reduces the fracture energy after optimum concentration. The TG analyses of toughened epoxy networks reflect the greater thermal stability of modified epoxy network than unmodified one. So it can be finally stated that brittle polymers are toughened most successfully by incorporating amine functional polymers into the glassy epoxy matrix without sacrificing the thermal properties of the epoxy resins. This is the significant goal of this work.

References

1. C. H. Klute and W. Viehmann, *Journal of Applied Polymer Science*, 5, 86 (1961)
2. W. G. Potter, "Epoxy Resins", Fliffe, London (1970).
3. C. A. May in *Epoxy Resins-Chemistry and Technology*, 2nd Edn, Marcel Dekker, New York (1988).
4. H. Lee and K. Neville, *Handbook of Epoxy resins*, McGraw-Hill, New York, (1967).
5. W. G. Potter, "Epoxy Resins", Fliffe, London (1970).
6. C. A. May in *Epoxy Resins-Chemistry and Technology*, 2nd Edn, Marcel Dekker, New York (1988).
7. R. S. Bauer in *Epoxy Resin Chemistry*, ACS Symposium Series, 114, American Chemical Society, Washington, DC (1979).
8. K. Hodd in *Comprehensive Polymer Chemistry*, Sir G. Allen (ed), Pergamon Press, Oxford, Vol. 5. Chap. 37, p. 667 (1989).
9. H. Lee and K. Neville, *Handbook of Epoxy Resin*, McGraw-Hill, New York (1967).
10. B. Sedlacek and J. Kahovec in *Crosslinked Epoxy*, de Gruyter, Berlin (1987).
11. J. N. Sultan, R. C. Laible and F. J. McGarry, *Journal of Applied Polymer Science*, 6, 127 (1971).
12. J. N. Sultan and F. J. McGarry, *Polymer Engineering and Science*, 13, 29 (1973).
13. A. M. Ramano, F. Garbassi, R. Braglia, *Journal of Applied Polymer Science*, 52, 1775 (1994).

14. X. He, H. C. Conner, J. A. Koutsky, *Journal of Polymer Science, Part A: Polymer Chemistry*, 30, 533 (1992).
15. A. Mija, C. N. Casaval, Gh. Stoica, D. Rosu, B. C. Simonescu, *European Polymer Journal*, 32, 779 (1996).
16. J-Y. Shieh, Ch-SJ. Wang, *Polymer Science Polymer Chemistry Edition*, 40, 369 (2002).
17. Y. Zhang, S. Vyazovkin, *Macromolecular Chemistry and Physics*, 206, 1084 (2005).
18. V. Strehmel, B. Strehme, S. Habich, *Polymer Preprints*, 39, 476 (1998).
19. D. Kim, J-O. Beak, Y. Choe, W. Kim, *Korean Journal of Chemical engineering*, 22, 755 (2005).
20. J. Go, Y. Li, *Polymer International*, 49, 1590 (2000).
21. V. L. Zvetkov, *Polymer*, 43, 1069 (2006).
22. A. Thakur, A. K. Banthia, B. R. Maiti, *Journal of Applied Polymer Science*, 58, 559 (1995).
23. T. Ozawa, *Bulletin of Chemical Society Japan*, 38, 1881 (1965).
24. T. Ozawa, *Journal of Thermal Analysis*, 2, 301 (1970).
25. J. L. Hedric, I. Yilgor, M. Jurek, J. C. Hedric, G. L. Wilkes and J. E. McGrath, *Polymer*, 32, 2020 (1991).
26. M. Ochi and J. P. Bell, *Journal of Applied Polymer Science*, 29, 1381 (1984).
27. D. J. Hourston, J. M. Lane, *Polymer*, 33, 1379 (1992).
28. S. Kunz, Ph D Thesis, University of Cambridge (1978).

Fibonacci numbers in real life applications

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Abstract

Fibonacci is one of the most famous mathematicians of the middle Ages. From his works Christian Europe was able to adapt a new numerical system that was the Hindu-Arabic decimal system. Fibonacci introduced the nine Indian figures: 9,8,7,6,5,4,3,2,1. He is most famous for his number sequence where after two values; each number then in turn is the sum of the preceding numbers. This sequence holds true to many occurrence in nature such as flower petals, nautilus shells etc. The Fibonacci numbers are also important in analyzing Euclid's algorithm in finding the greatest common divisor of two integers. It was also use pseudorandom number generators and one dimensional optimization method. The Fibonacci numbers share an interesting connection with the triangle of binomial coefficients known as Pascal's triangle.

Keywords: Sequence, numerical system, integer, Pseudorandom, binomial coefficient.

1. Introduction

Fibonacci is a nickname that was given to man by the name of Leonardo Pisano. He was born in 1170 to an Italian merchant, Guilielmo, who represents of the republic of the Republic of Pisa in Nothern America. So Fibonacci was taught mathematics in Bajaia, Algeria, where his father held's his post. As a merchant's son, Fibonacci often travelled with his father to numerous countries for trading purposes, from these visits, he became increasingly interested in the mathematical systems that were used by them. Some of the most influential countries to his studies were Egypt, Syria, Greece, Sicily and Provence, all located around the Mediterranean Sea. Upon returning to Pisa in the year 1200, Fibonacci produced a numerous important mathematical texts that introduced the Christian Europe to the new Hindu-Arabic place valued decimal system. His texts included *Practica geometriae*, *Flos*, *Liber quadratorum*, the widely known *Liber abaci*. Before the works of Fibonacci, Christian Europe only used the Roman numeral as their main number systems, but with the introduction of the new

decimal system, western economics practices and book keeping never been the same. During his time in Pisa, Fibonacci was introduced to Fedrick II, the Holy Roman Emperor. Fedrick II was aware of Fibonacci's work through the court's of scholars, who known Fibonacci since his return to Italy. The Holy Roman Emperor employed Fibonacci as an advisor for accounting and educating the citizens of his empire. The term

Fibonacci number is used to describe the series of numbers generated by the pattern: 1,1,2,3,5,8,13,21,34,55,89,144,....., where each number in the sequence is given by the sum of the previous two terms [1]. Fibonacci contributed a great deal to the world of mathematic; however his most famous contribution is the well known Fibonacci sequence. The sequence is a recurrence relation where after two starting values, each number is the sum of the two preceding numbers.

Now we shall discuss the Fibonacci sequence, with the help of the following rabbits problem. How many pairs of rabbits will be produced in a year, beginning with a single pair, if in every month each pair bears a new pair which becomes productive from the second month on? (Suppose that our rabbits never die and that the female always produce one pair: one male, one female).

Here the Fibonacci numbers are originally used to represent the number of pairs of rabbits born of one pair in a certain population. Let us assume that a pair of rabbit is introduced into a certain place in the first month of the year. This pair of rabbits will produce one pair of offspring every month, and every pair of rabbit will begin to reproduce exactly two months after being born. No rabbits ever dies, and every pair of rabbit will reproduce perfectly on schedule. So clearly in the first month, we have only the first pair of rabbit. Likewise, in the second month, we again have only our initial pair of rabbit. However by the third month, the pair will give birth to another pair of rabbit, and there will now be two pairs. Continuing on, we find that in the month four we will have 3 pairs, then 5 pairs in the month five. After a while,

The population will expand rapidly and we will have the following sequence:

$$1,1,2,3,5,8,13,21,34,55,89,144,..... \quad . \quad \text{This is known as the recursive or Fibonacci sequence. This sequence could be written as the following:}$$

$$u_1 = 1, u_2 = 1, u_3 = 2, \dots \dots \dots, u_n = u_{n-1} + u_{n-2}, n > 2, n \in N \quad \text{---}$$

--- (i)

$$u_1 = 1, u_2 = 1, u_3 = 2, \dots \dots \dots, u_n = u_{n-1} + u_{n-2}, n > 2, n \in N \quad \text{---}$$

--- (i)

Fibonacci sequences appear in many different biological phenomenons, such as the curve of waves, the arrangement of a pine cone or the spiral of a nautilus shell. The Fibonacci sequence 1, 1, 2, 3, 5, 8, . . . , is used in mathematical programming to find the interval containing the minimize of a function of a one variable.

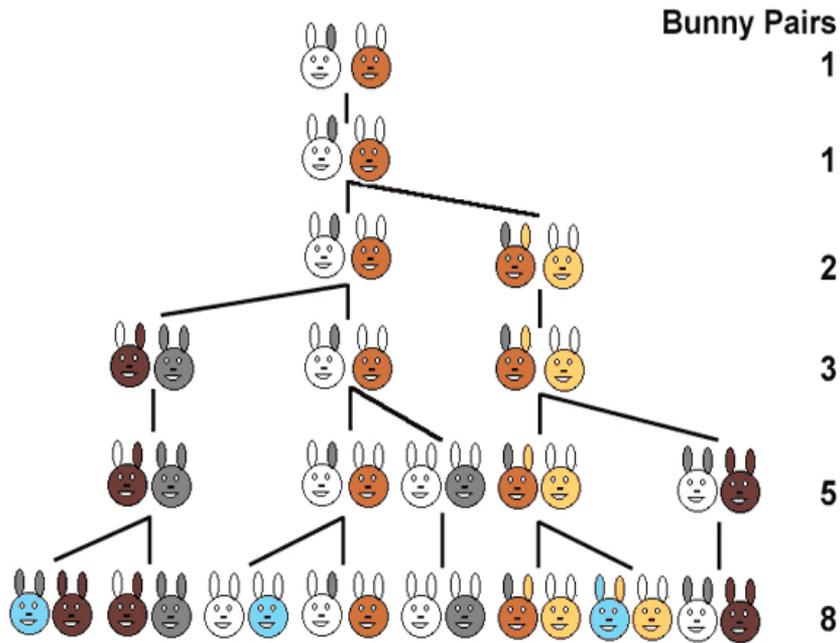


Figure 1 Fibonacci sequence is created by Rabbits problem .

So this recurrence relationship seems to be quite simple, where 1 and 1 are 2, 1 and 2 are 3, 2 and 3 are 5, 5 and 3 are 8, and so on [2] . However this relationship is quite applicable to many different topics, from the growth patterns of plants to tuning musical instruments. If we apply Fibonacci sequence on a rectangle having length 34 units and width 21 units (see figure-2) we will get Fibonacci spiral, Golden mean and Golden rectangle. The Golden rectangle is a famous concept related to aesthetics and mathematics. It is found in many natural and man-made things on Earth.

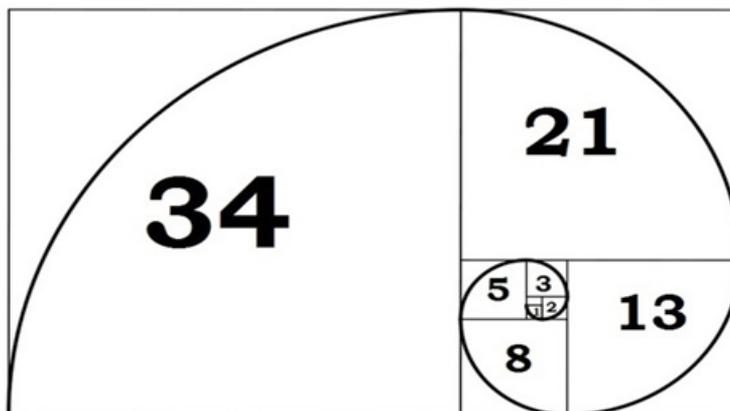


Figure 2 Fibonacci spiral.

As one can see the rectangle is composed of multiple square that have the sides whose lengths follow the Fibonacci sequence. The squares are positioning, where it's spiraling outward. Then the ratio of the length to width of those squares is the ratio of the two successive terms of the Fibonacci sequence. So the new Fibonacci sequence becomes:

$$\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \frac{21}{13}, \frac{34}{21}, \dots \dots$$

$$\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \frac{21}{13}, \frac{34}{21}, \dots \dots$$

Let the $n^{\text{th}}n^{\text{th}}$ term of the above sequence to be equal to $x_n x_n$, so the sequence becomes :

$$x_1 = \frac{1}{1}, x_2 = \frac{2}{1}, x_3 = \frac{3}{2}, \dots \dots, x_n = \frac{u_{n+1}}{u_n}, \dots \dots$$

Therefore from equation (i), we then have:

$$x_n = \frac{u_{n+1}}{u_n} = 1 + \frac{u_{n-1}}{u_n}$$

$$= 1 + \frac{1}{\frac{u_n}{u_{n-1}}} = 1 + \frac{1}{\frac{u_{n-1}}{u_{n-2}}}$$

$$= 1 + \frac{1}{x_{n-1}} = 1 + \frac{1}{x_{n-1}}$$

If the sequence converges to a real number xx , then $x_n x_n$ and $x_{n-1} x_{n-1}$ have the same limit, where the real number xx must have the following equation:

$$x = 1 + \frac{1}{x}$$

$$\text{or, } x^2 - x - 1 = 0 \quad x^2 - x - 1 = 0$$

$$\text{or, } x = \frac{1 \pm \sqrt{5}}{2} \quad x = \frac{1 \pm \sqrt{5}}{2}$$

Taking positive sign, the value of xx therefore equal to : $\frac{1+\sqrt{5}}{2}$ $\frac{1+\sqrt{5}}{2}$

This number is known as the Golden Mean, and the rectangle above is therefore known as the Golden Rectangle.

2. The Golden Ratio

In calculating the ratio of two successive Fibonacci numbers $\frac{u_{n+1}}{u_n}$, we find that as n increases without bound, the ratio approaches $\frac{1+\sqrt{5}}{2}$, i.e.

$$\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = \frac{1+\sqrt{5}}{2} \quad \lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = \frac{1+\sqrt{5}}{2}.$$

Proof: Since the Fibonacci numbers satisfy the following recurrence relation:

$$u_{n+1} = u_n + u_{n-1}$$

$$\text{or, } \frac{u_{n+1}}{u_n} = 1 + \frac{u_{n-1}}{u_n}$$

Now let, $\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = L$, $\lim_{n \rightarrow \infty} \frac{u_{n-1}}{u_n} = L$, therefore

$$\lim_{n \rightarrow \infty} \frac{u_{n-1}}{u_n} = \frac{1}{L} \lim_{n \rightarrow \infty} \frac{u_{n-1}}{u_n} = \frac{1}{L}$$

Now we have the statement, $\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = 1 + \lim_{n \rightarrow \infty} \frac{u_{n-1}}{u_n}$

$\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = 1 + \lim_{n \rightarrow \infty} \frac{u_{n-1}}{u_n}$, which is equivalent to the equation

$$L = 1 + \frac{1}{L}L = 1 + \frac{1}{L}, \text{ this equation can then be rewritten as } L^2 - L - 1 = 0, \\ L^2 - L - 1 = 0,$$

Which is easily solved by quadratic formula. By using the quadratic formula, we have

$$L = \frac{1 \pm \sqrt{5}}{2}.$$

Thus we arrive at our desired result of ; $\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = \frac{1+\sqrt{5}}{2}$

$$\lim_{n \rightarrow \infty} \frac{u_{n+1}}{u_n} = \frac{1+\sqrt{5}}{2}$$

Even for relatively low values of n, n , this ratio produces a small error.

For example, $\frac{u_{11}}{u_{10}} = \frac{89}{55} \approx 1.6182, \frac{u_{11}}{u_{10}} = \frac{89}{55} \approx 1.6182,$ and

$$\frac{1+\sqrt{5}}{2} \approx 1.6180, \frac{1+\sqrt{5}}{2} \approx 1.6180.$$

The value $\frac{1+\sqrt{5}}{2}$ is the positive root of the quadratic equation $x^2 - x - 1 = 0$.

It arises often enough in mathematics and has such interesting properties that we also frequently refer to it as Golden Ratio [3]. In mathematical terms phi (ϕ) is used as the symbol for the Golden ratio 1.61803398875. The Golden ratio is used to construct pentagram. Pythagoras believed that this proportion that revealed the hand of God. Astronomus Johanues Kepler saw phi (ϕ) as the greatest treasure of geometry. Phi (ϕ) was the perfect proportion to all the artwork, sculpture and agriculture [4].

Fibonacci Identity1: The sum of the first n Fibonacci numbers can be expressed as

$$u_1 + u_2 + u_3 + \dots + u_{n-1} + u_n = u_{n+2} - 1$$

Proof: From the definition of the Fibonacci sequence, we know

$$u_1 = u_3 - u_2$$

$$u_2 = u_4 - u_3, u_3 = u_5 - u_4$$

$$\text{So, } u_{n-1} = u_{n+1} - u_n, u_{n-1} = u_{n+1} - u_n$$

$$u_n = u_{n+2} - u_{n+1}$$

We now add these equations to find

$$u_1 + u_2 + u_3 + \dots + u_{n-1} + u_n = u_{n+2} - u_2$$

Recalling that $u_2 = 1u_2 = 1$, we see this equation is equivalent to our initial conjecture of

$$u_1 + u_2 + u_3 + \dots + u_{n-1} + u_n = u_{n+2} - 1$$

Fibonacci Identity2: The sum of the squares of the first n Fibonacci numbers can be expressed as

$$u_1^2 + u_2^2 + u_3^2 + \dots + u_{n-1}^2 + u_n^2 = u_n u_{n+1}$$

Proof: Note that

$$u_k u_{k+1} - u_{k-1} u_k = u_k (u_{k+1} - u_{k-1}) = u_k^2$$

So we get, $u_1^2 = u_1 u_2 u_1 = u_1 u_2$

$$u_2^2 = u_2 u_3 - u_1 u_2$$

$$u_3^2 = u_3 u_4 - u_2 u_3$$

$$u_n^2 = u_n u_{n+1} - u_{n-1} u_n$$

Now we add these equations, we arrive at the formula

$$u_1^2 + u_2^2 + u_3^2 + \dots + u_{n-1}^2 + u_n^2 = u_n u_{n+1}$$

Identity 3: Difference of squares of Fibonacci Numbers

$$u_{n+1}^2 - u_{n-1}^2 = u_{2n}$$

Proof: We know that, $u_{2n} = u_n u_{n+1} + u_{n-1} u_n = u_n u_{n+1} + u_{n-1} u_n$

$$= u_n (u_{n-1} + u_{n+1}) = u_n (u_{n-1} + u_{n+1}), \quad \text{since}$$

$u_{n+m} = u_{n-1} u_m + u_n u_{m+1}$ and taking

$$m = n$$

and since, $u_n = u_{n+1} - u_{n-1}$

We can rewrite the formula as follows:

$$\text{or, } u_{n+1}^2 - u_{n-1}^2 = u_{2n} u_{n+1} - u_{n-1}^2 = u_{2n}$$

Brahmagupta-Fibonacci Identity: Brahmagupta-Fibonacci Identity is actually first found in Diophantus Arithmetica (III, 19), of the third A.D. It was rediscovered by Brahmagupta (598-668), an Indian mathematician and astronomer, who generalized it (to Brahmagupta identity) and used it in his study of what is now called Pell's equation. This identity is equivalent to

$$\begin{aligned}(a^2 + nb^2)(c^2 + nd^2) &= (ac - nbd)^2 + n(ad + bc)^2 \\(a^2 + nb^2)(c^2 + nd^2) &= (ac - nbd)^2 + n(ad + bc)^2 \dots\dots(ii) \\&= (ac + nbd)^2 + n(ad - bc)^2 (ac + nbd)^2 + n(ad - bc)^2 \dots(iii)\end{aligned}$$

This shows that for any fixed A, the set of all numbers of the form $x^2 + Ay^2$ closed under multiplication. The identity holds in the ring of integers, the ring of rational numbers, and more generally, commutative ring. The identities can be verified by expanding each side of the equation and also (ii) can be obtained from (iii) or (iii) can be obtained from (ii), by changing bb by $-b.-b$.

3. Conclusion:

In this review, we have introduced Fibonacci numbers in a popular way. We can construct Pascal's triangle using the Fibonacci numbers. The Fibonacci sequence is used thunders and many features of nature. Applications of Fibonacci numbers include computer algorithms such as the Fibonacci search technique and the Fibonacci heap data structure, and graphs called Fibonacci cubes used for interconnecting parallel and distributed systems. They also appear in biological settings, such as branching in trees, phyllotaxis (the arrangement of leaves on a stem), the fruit sprouts a pineapple, the flowering of an artichoke, an uncurling fern and the arrangement of a pine cone's bracts. The Fibonacci sequence appears in Indian mathematics, in connection with Sanskrit prosody. The Fibonacci numbers are important in the computational run-time analysis of Euclid's algorithm to determine the greatest common divisor of two integers: the worst case input for this algorithm is a pair of consecutive Fibonacci numbers. Yuri Matiyasevich was able to show that the Fibonacci numbers can be defined by a Diophantine equation, which led to his solving Hilbert's tenth problem. This introductory article do not deal with every possibility there are plenty of possibilities left for interested readers.

References:

1. Burton,D., (2007) *Elementary Number Theory*, 6th edition, McGraw Hill Higher Education, New York.
2. Hoggatt, V. E. Jr. (1969). *The Fibonacci and Lucas Numbers*. Boston, MA: Houghton Mifflin.
3. Knott, R (12th June1299). The Golden Section Ratio, "<http://www.mcs.surrey.ac.uk/Personal/R.Knott/Fibonacci/phi.html>"
4. Fibonacci number – Wikipedia, https://en.wikipedia.org/wiki/Fibonacci_number

Geography: A Science by Inception

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Abstract

Geography, as a subject, often invites debate on misperceptions and criticisms regarding its inclusion in the study of science. The subject, though known to have originated from scientific parenthood, is thought to have lost its maturity in due course with the addition of human elements in it. However, the subject, in actual practice, flowered into other spheres of human knowledge thereby keeping its integrity with physical science, intact. The paper challenges this issue of defenestration thereby trying to synchronize the subject of Geography with the most ancient branch of science known, i.e, mathematics and astronomy. Here, the shape confusion of the Earth is discussed along with the discussion on Datum. How Datum originates and what are the complexity a map maker faces in geography and how its solution is backed upon by mathematics. With the elaboration of the debate of the shape of the Earth, the science of Geography encompasses other scientific domain and its course of study encompasses all. The paper is rational, imperative, informative and scientific in approach. Taking a beginner's view, the paper tries to elaborate on the origin of geographical information, in particular and scientific study, in particular.

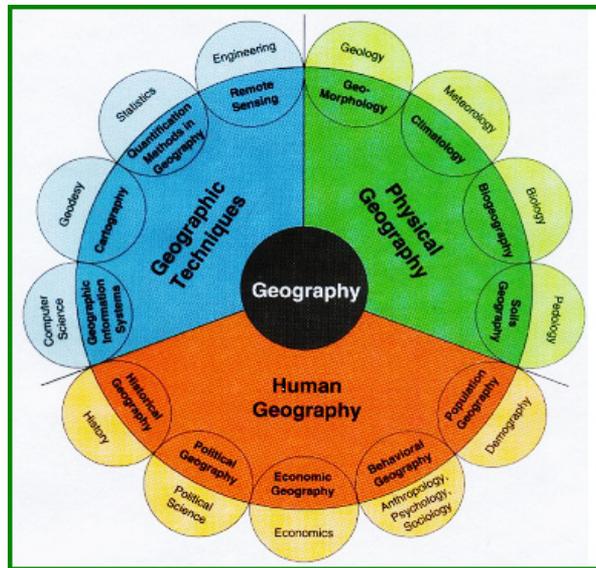
Keywords: *Geography, Science, Earth, Shape, Geodesy, Datum.*

1. Introduction

“Geography explains the past, illuminates the present and prepares us for the future”. These words of Michael Palin makes the study of the subject of geography more essential than desirable. The subject intrudes into the various facets of the physicality of the Earth and cultural setup of the society at the same time and elaborates on its understanding. Even for a beginner, or for an apprentice of any walks of life, it is necessary to know his surroundings in a

micro level and world, in macro analysis. There lies the entry of Geography crossing the threshold of the classification of Physical Science, or Social Science or Non Science.

As defined strictly on its academic mode, Geography is the study of the Earth and its various features. Here, the study is defined as having a physical basis, which however was challenged later on to include the life of its inhabitants, thereby including the social dimension to the study. Thus, the study of Geography is essentially manifold in approach depending on the visual choice of the reader/ practitioner and is the subject, in actual practice, flowered into other spheres of human knowledge thereby



keeping its integrity with physical science, intact. The subject of Geography entered the multidisciplinary periphery long back and was not rigid in its form, like other branches of physical science. This adaptability of the subject is often debated upon. Despite of being strong at analysis and substantial in approach, due to its ability to encircle one and all, the subject is rather thought to have degenerated. The subject is however, multidisciplinary in the method, where it includes the study of all other subject into its domain.

2. The Science in Geography

As a broad discipline, the subject incorporates the study of Earth and donates to the study of science as a part of the comprehensive, original as well as unique effort to improve knowledge. As a scientific study incorporates the research on original experimentation, the subject matter of Geography deals with the various features of the Earth and Space and investigates the various reasons of its existence. The study is definite, rational, inimitable and quantitative. As a scientific study, the main focus of the study of Geography is the study of Earth, its shape and its features. This unifies it with Physics (Geodesy) and Geology.

3. The Great Confusion of Shape

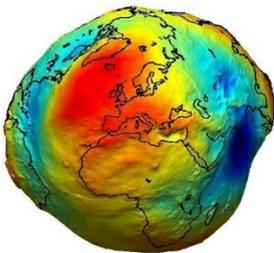
Before any scientific experiment be commenced, it is very important for the scientist to clear any and every confusion of its subject. Likewise, before the scientific study of the Earth began, various Geographers (most of them were philosophers and mathematicians) tried to investigate on the shape of the Earth as the basic understanding of the subject. But, it was however, not an easy task, since, at those times, it was impossible to see Earth from outside, with the help of space ships and other astronomical instruments. Thus emerged various debates.

In early Mesopotamian mythology, the world was represented as a flat disk floating in the ocean with a hemispherical sky-dome above. As was put forward by Otto Eduard Neugebauer, a historian of science, by the study of the cuneiform, the first written script of Mesopotamian (Sumerian and Semitic) civilization, mentioned about the Sun, Moon and Star embedded solid dome that surrounded the Earth. Similar observations are also seen in Egyptian literatures and also in Homeric account. Later on, with the advent of Hellenistic astronomy, Eratosthenes, Pythagoras, Ptolemy, Strabo, Archimedes and other Greek philosophers, the spherical shape of the Earth was first imagined. Also, a practical demonstration of the shape of the Earth (sphericity) was attained by Magellan and Sebastian Elcano during their expedition Circumnavigation (1519-1522) that started in Spain and returned there after crossing the Atlantic, Pacific and Indian Ocean. Even in India, Aryabhata, the mathematician put forward the concept of spherical Earth. During 17th century, however, the shape of the Earth was accurately calculated and defined as an Ellipsoid by Sir Isaac Newton.

However, in modern scientific analysis, the study regarding the shape of the Earth gained further impetus, with the development of science. Even before the advent of Geoinformatics that gathers information about our planet, the subject of Geodesy formulated various analysis about the shape of the Earth and it was clearly understood that the whole study of the Geography as a science encompasses around one single confusion regarding the shape of the Earth.

4. The Great Dexterity of Shape

The shape of the Earth, as was seen is not a smooth ellipsoid. Due to the uneven distribution of the Earth's mass the Earth gained the shape named Geoid or "Earth like." This Geoid, as is explained by the scientist, accords with the surface to which the oceans would conform over the entire Earth if free to adjust to the combined effect of gravitation and the centrifugal force of the Earth's rotation.

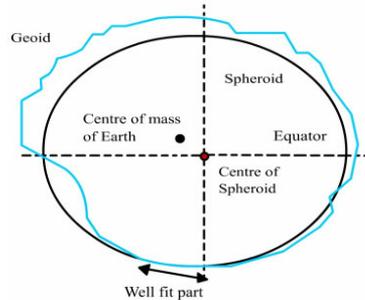


Along Geoid surface, the gravity potential is equal everywhere along which the gravity direction is perpendicular, i.e., an equipotential surface of electric voltage, where often the electric field acts perpendicular.

Due to this unusual shape of the Earth, which according to Gauss, is the "mathematical figure of Earth", there was a problem of calculation of the various attributes of geographical representation. Geography, being a spatial science, it involves experimentation and analysis which can practically be proven and can be answered through mathematical intervention, along with field scrutiny, simple harmonics of mathematics are applied to get a uniform result. Thus, emerged the concept of Datum, which is nothing but a mathematical model which approximates the weird shape of the Earth to enable accurate position, length and area calculations.

Datums are very important, not only in theoretical geographic analysis, but can also be used in Survey, Geodesy, cartographic plotting in the field area to develop an inference about the Earth’s surface which can later be used by mathematician or physicist as an aid to their experimentation. Also, the use of Datum in in satellite navigation system and Geographic Information System can help to translate positions indicated on maps to the real position on Earth.

This Datum, though is taken by geoscientists, for an impeccable calculation of and about Earth, it triggered several more complications. One of them is the location of the Centre of the datum surface that does not fit with the geoid Centre and if and when areas are calculated through it, a wrong and flawed inference is drawn. Also, the bizarre shape of the Earth does not allow one datum line to correspond and cover the whole of the Earth in general. Some places are, and will always be left out. So, other than choosing an universal datum line like World Geodetic System 1984 (WGS 84), local Datum lines are also drawn to fit requirement of other countries. For example the OSGB36 datum of Great Britain of 1936. And NAD27 and NAD83 (North American Datum of 1983). WGS 83 is a global datum, while, NAD 83 is a local datum, both, however, is used in Global Positioning System (GPS) owing to the fact that their origin are at the center of the Earth’s mass.



In order to create a geodetic datum, surveyors undertook an enormous gathering of monument locations in the late 1800s. Surveyors installed brass or aluminum disks at each reference location, which were connected by mathematical techniques like triangulation survey. Thus, with the creation or conception of Datum, there was a convenience of selecting positions on the Earth and transferring them on Map. This involved a change of points from three dimensional body (here, Earth) to a two dimensional plane (the map, in this case). The methods applied to transfer the coordinates from the curved surface of the Earth to the map, is thus known as Projection.

The North American Datum (both 27 and 83) serve local purpose, to highlight and enlighten a part of local mapping. They are more or less accurate in their measurement, however, overlapping of theses datum in one area cause a difference in coordinates of one place. This is commonly known as Datum Shift, which may vary from one pace to another and can be anything from zero to hundreds of kilometers. An example can be sited, in this regard, which is too dangerous in its concluding phrase. In one single example point in Cameroon, West Africa, in different Datum shows different coordinate locations.

GeogCRS/Datum	Latitude (N)	Longitude
Manoca	04°04' 17.179" N	008°29' 43.774"E
Minna	04°04' 12.077"N	008°29' 41.572"E
WGS 84	04°04' 14.504"N	008°29' 39.351"E

Thus, with the use of different datum, discrepancy in interpolations for the precise shape and size of the Earth may take place. Thus, the benefits of using a global datum like

WGS 84 outweighs the greater accuracy claimed by local datum. The two areas where this Datum shift mattered the most is in Field Survey, where GPS tracker is taken and in GIS where data are projected in coordinate system. The datum shift can often result in disaster where the mapping may cripple the actual work of development of a country/ area. So, to check the above irrationality, a datum transformation becomes absolute necessity. For this Datum transformation, a set of mathematical formula is required that converts or superimpose point coordinated from one datum to another. Several parametric and non-parametric methods are used in this regard.

Thus, the confusion of shape resulted in the foundation, creation and ignition of the new era in Geography in particular and Science in general. Geoinformatics is the new science that developed from the womb of Geography and walked holding the hands of Mathematics. As a large domain of study of science, the subject enters the field of Earth Science thereby inspecting the Physics, Chemistry and Biology of our planet and mathematically concluding it. It enhances the eternal focus of the subject of geography on the most important issue any science can deal upon with: the concept of wellbeing and the contribution of scientific knowledge in that measure

5. Conclusion

Without going into much intricacies of other geographical understandings and emphasis, it will not be wrong to conclude that the the essence of the study of Geography is to study the Earth as our home. Geography integrates places, speaks of interdependencies between places, works to focus and analyze on difference in scales. Be it in the group of humanities or scientific study, the subject always has and had a CLASS OF ITS OWN.

List of References:

1. Geodesy for the Layman, Chapter VIII, "*The World Geodetic System*",
2. Brown, L.A.; A Story of Maps; Little, Brown and Company; Boston, Massachusetts; 1950
3. Ewing, C.E. and M.M. Mitchell; Introduction to Geodesy; American Elsevier Publishing Company, Inc.; New York, New York; 1970.
4. Stokes, G.G., 1849: On the variation of gravity at the surface of the Earth, *Transactions of the Cambridge Philosophical Society*, V. 8, p. 672.

Websites:

1. <https://web.archive.org/web/20120402143802/https://www1.nga.mil/ProductsServices/GeodesyandGeophysics/WorldGeodeticSystem/Pages/default.aspx>
2. berkeley.edu/documents/Projections_Datums.pdf
3. EPSG guidance note 7, downloaded from, www.epsg.org
4. Wikipedia
5. Datums, Coordinate systems, Coordinate Reference systems, and Datum Transformations. http://2007.foss4g.org/labs/L-03/FOSS4G2007_APSG_VictoriaBC.pdf

A project on crustacean larva, their life cycle, evolution and importance

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Abstract

This project is basically on the stage abundance and spatial distribution of five taxa of crustacean larva whose adult populations inhabit different depth ranges in the coastal area of central Chile. My goal is to identify the relationship between the timing and depth range of larval release, with larval depth distribution and behaviour, and offshore transport during early upwelling season and upwelling reversal. *Emerita analoga* larvae were mainly released in the intertidal off phase in the season of maximum upwelling intensity. *E. analoga* was the shallowest larvae in this study, the most widespread in the horizontal plane and no detail vertical migrations were observed. *Blepharitis spinimana*, another intertidal species, was always restricted to coastal stations and were mainly released during summer it is a shallow species and, at our sampling scale, we could not identify vertical behaviour. *Libidoclaeagrana* larvae were released in the continental shelf during the more intense upwelling season. Zoea larvae are wide spread horizontally and Zoea larva appeared closer to coast. They did not show vertical migration, they were found widespread in the water column and they were deepest larvae. Larvae that migrated vertically were released over a long period during the upwelling season (summer months), from the subtidal environment. So in this context different crustacean larva, their distribution, habits, characters, life history, evolutionary significance etc. are reviewed in details.

Keywords: crustacea, larva, evolution, phylogenetic tree, economic importance

1. Introduction

Crustaceans are the major arthropods whose body is covered by chitinous exoskeleton structures for protection. This exoskeleton does not allow body growth and thus shed in order to allow growth. The larval stages feed and grow in order to become adults and must undergo moulting or ecdysis. After each and hence there are different from previous stages (John, 1995, 1997).

Crustacea involves both direct and indirect development in their life cycle (Calman, 1911). The offspring that hatched from eggs resembles their parent known as direct or epimorphic development. When newly hatched young one is different from their adult, it acquires adult hood after number of changes, such development is called indirect or metamorphic development (Crustacean Glossary, 2016).

Larva is an important stage in the development of many animals, occurring after birth or hatching. These immature active forms are structurally different from the adults and are adapted to a different environment (Ruppert and Barnes, 1994). Crustaceans show both direct and indirect development. In direct development, the adult has progressive growth and differentiation of the embryo. So, newly hatched young resembles the parents. Manly of the crustaceans undergo indirect development, involving a wide variety of larval forms (Hymen, 2015). Among all the different larval forms, three major larval forms are Nauplius, Zoea, and Megalopa larva and others are metanauplius, cypris and protozoea larva (Table 1).

2. Distribution, Habits and Habitats

They are commonly found at tropical soft bottom habitats. They are also distributed at vegetated habitats and tropical shallow soft bottom habitats. They live in water, but some are found at land also crustaceans are commonly found in the oceans, but some are also found in fresh water (Chatterjee and Charkrabarti, 2016). Crustaceans are commonly found in rivers, ponds and other fresh water areas. They are nocturnal bottom dweller and lives within under water crevices and aquatic vegetation. It takes all kinds of food specially decaying leaves (Ganguly et al., 2014). They are good swimmer but they are also capable of crawling on the surface they have a length of seventy five centimeters.

3. Life cycle of crustacean larva

A crustacean's life cycle begins with an egg, which is usually fertilized, but may instead be produced by parthenogenesis (Alberto, 2007). This egg hatches into a pre-larva or pre-zoea. Through a series of moults, the young animal then passes through various zoea stages, followed by a megalopa or post-larva. This is followed by metamorphosis into an immature form, which broadly resembles the adult, and after further moults, the adult form is finally reached (Alberto et al., 2007). Some crustaceans continue to moult as adults, while for others, the development of gonads signals the final moult (Hymen, 2015).

Any organs which are absent from the adults do not generally appear in the larvae, although there are a few exceptions, such as the vestige of the fourth pereopod in the larvae of *Lucifer*, and some pleopods in certain *Anomura* and crabs (Gurney, 1942). Also, the *Sacculina* and other *Rhizocephala* have a distinctive nauplius larva with its complex body structure, but the adult form lacks many organs due to extreme adaptation to its parasitic life style (Fig. 1).

4. Crustacean metamorphosis

Crustaceans display some of the most spectacular metamorphosis from free-swimming meroplankton to reef-dwelling adult. The slipper lobster show metamorphic changes

from spindly larva to the heavily plated and brightly coloured adult (John et al., 1995). Slipper lobsters are closely related to rock lobsters but have a flattened body and short, wide antennae (Fig. 2).

The adult mantis shrimp are often beautifully coloured in shades of red, green and blue. They also show cyclical metamorphosis from larval stages to adult prawns. They capture their prey using large claws to smash or spear their victims (Jerome, 2010).

5. Systematic position with salient features of each crustacean larva

Zoea larva

Systematic position

Kingdom-Animalia
Phylum-Arthropoda
Class-Crustacea
Subclass-Malacostraca
Specimen- Zoea

Salient Features

Unsegmented cephalothorax and long abdomen. The first two pairs of maxillipedes are well developed. Six pairs of thoracic appendages are in the forms of buds. Presence of one pair of compound eyes. Antennule and antenna are short and sensory in function (Fig. 3).

Example: Zoea (Larval form) and Crab (Adult form).

Mysis larva

Systematic position

Kingdom-Animalia
Phylum-Arthropoda
Class-Crustacea
Subclass-Malacostraca
Specimen-Mysis

Salient Features

They look like a miniature prawn, contains head and thorax covered by a carapace. All thoracic appendages are like and biramous with enopodites. Head bears antennules, antenna and pair of eyes.

Example: Mysis (Larval form)-Prawn (Adult form).

Megalopa larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Specimen-Megalopa

Salient Features

Body is divisible into cephalothorax and six segmented abdomen. The carapace is large and drawn into a spine in front this body. Thoracic appendages are paired which are well developed (Fig. 3).

Example:- Megalopa (Larval form) and Crab(Adult form).

Nauplius larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Specimen-Nauplius

Salient Features

Salient Features

Larva has unsegmented body, some are oval in shape with a broad, anterior and narrow posterior end. Their body is divisible into head, trunk and bilobed anal region. A median eye and a mouth present at the anterior region. They have three pairs of unjointed appendages with numerous stages (Fig. 3).

Example: Nauplius (larval form) and Cyclops (adult form).

Alima larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Specimen- Alima.

Salient Features

The Alima larva of squilla, which hatched out to modified Zoea larva. Anterior cephalothorax produced into rostrum. The abdomen is segmented and has four pair of appendages and in telson (Fig. 3).

Example: Alima (larval form) and Squilla (adult form)

Cypris larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Subclass-Ostracoda
 Specimen- Cypris.

Salient Features

Body of Cypris is enclosed into a bivalve shell which is secured by an adductor muscles. There are six pairs of biramous thoracic appendages for swimming. There is one pair of compound eye the antennule is large and especially modified for attachment to substratum with cement gland, the second antennae is absent (Fig. 3).

Example: Cypris (larval form) and Cypris (adult form).

Phyllosoma larva**Systematic position:**

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Subclass-Malacostraca
 Specimen- Phyllosoma.

Salient Features

There is a pair of stalked compound eyes and a pair each of antennules and antenna as sense organ. Body is dorsoventally flattened and transparent. The abdomen is small, segmented and does not bear appendages. Body is divided head, thorax and abdomen (Fig. 4).

Example: Phyllosoma (larval form) and Palinurus (adult form).

Decapoda larva**Systematic position**

Kingdom- Animalia
 Phylum- Arthropoda
 Class- Crustacea
 ubclass-Malacostraca
 Specimen- Decapoda.

Salient Features

They have 8 pairs of thoracic appendages. 5 pairs of appendages are considered as the 10 legs, hence the name decapoda and front 3 pairs of appendages function as mouth parts(maxillipeds). 1 pair of legs (chelipeds) are enlarged pincers claws called chelae (Fig. 4).

Example: Decapoda (larval form) and Decapoda (adult form).

Cyclops larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Subclass-Copepoda
 Specimen-Cyclops.

Salient Features

The Cyclops has a pair of legs and divided tail- like appendages called a furca. The Cyclops is very small, about 2-3 mm long with one antenna or red eye middle of its head. Cephalothorax covered with a carapace. Body elongated with a broad cephalothorax and a narrow abdomen. In nature females two lateral quises are attached to the abdomen (Fig. 4).

Example: Cyclops(larval form) and Cyclops(adult form).

Daphnia larva

Systematic position

Kingdom-Animalia
 Phylum-Arthropoda
 Class-Crustacea
 Subclass-Branchiopoda
 Specimen- Daphnia.

Salient Features

Body is bilaterally compressed. A bivalve carapace enclosed body and appendages. Carapace is drawn into an anterior rostrum and a posterior caudal spine. Eyes are large and sessile. Second antennae is long and biramous (Fig. 4).

Example: Daphnia(larval form) and Daphnia(adult form).

6. Field visit and study on crustacean larva in prawn culture farm

We have studied the details about the process of prawn culture, characters and structures of shrimps which are the larval forms of prawn, their habit, habitat, etc. at nearby of our college premises. There we found different prawn culture farms which are well equipped and fully organized to culture different prawn varieties like *Penaeus*, *Macrobrachium*, etc. Their culture practice and knowledge of prawn farming from the immature seed/ larval stage to marketable adult stage give a vast idea and information to us in relation to crustacean culture practice and their life cycle (Fig. 5).

7. Brief discussion about culture practice and mode of process

More or less warm climate with 34° to 35° C is suitable for prawn culture. Soil quality should be mixture of sand and mud and water quality is brackish with pH 7.5-8 and ppt is 12-15. The cultured pond should be 2000sq/feet in size and 6-8 feet in depth. Well planned water supply with proper inlet system should present in a prawn culture pond. A prawn larva took nearly 14-15 days to reach the post larval form (Fig. 5). The adult will take nearly 90 days to complete its marketable size of 30-40 grams. Rice grains, squid liver oil, etc. are some important food supplements for a suitable prawn culture.

8. Evolutionary significance

There are some significant evolutionary characters found in crustaceans which highlight the importance of them regarding their phylogeny also (Lipke et al., 1991). They help in the dispersal of species. They help to study the different group of crustacean. The larval stages are useful in finding the homologies and affinity of various groups. Larvae are helpful in the wide distribution of species and in keeping the food reserves of eggs. The larval stage is useful for finding out the homologies and affinities among various groups (Joachim et al., 2008; Jerome et al., 2010). It is evident that primitive crustaceans pass only through nauplius stage.

9. Economic importance of different crustacean larva and their adults

Human food: The large decapod crustacean (shrimps, crabs and lobsters) their larva provided delicious crustacean food many small crustacean, however, can be caught in such vast numbers and bulk that they become of considerable value (Lipke, 1991). Such crustaceans are often made into pastes.

Public health: Various crustaceans in both larva and adult forms intermediate hosts of certain parasitic worms whose final host is man. The lung fluke *paragonimus ringeri*, of Asia and south America, has as its second hosts a fresh water crab or crayfish. Man becomes the final host by eating a raw or undercooked second host. Infection leads to a chronic bronchitis.

Industrial damage: One of the most serious crustacean pests is the barnacle, which often attaches itself to ship hulls. A heavy layer of barnacles and other fouling organisms can increase by 50% the amount of fuel needed to maintain a given speed. Fouling by barnacles is greatest in the tropics. When the vessel is in front, it cannot attach itself to a moving ship.

10. Conclusion

Crustacea is their development under go various larval stages with increasing complexity. As the nauplius larva present in majority of crustacean life cycle, hence, it is believed that all crustacean have evolved from the common ancestor which resembles to nauplius larva. The other larva (zoa, mysis, metanauplius etc.) show the stage of evolution of higher crustacean from the nauplius like ancestor.

References

1. Alberto Addis; Francesca Biagi; Antonello Floris; Emiliana Puddu; Marcella Carcupino, 2007. "Larval development of *Lightiella magdalenina* (Crustacea, Cephalocarida)". *Marine Biology*. 152 (3): 733–744.
2. Calman, William Thomas; 1911. "Crustacea". In Chisholm, Hugh. *Encyclopædia Britannica*. 7 (11th ed.). Cambridge University Press., 552.
3. Chatterjee and Charkrabarti, *Practical Zoology*, 2016-17
4. Crustacean Glossary. Natural History Museum of Los Angeles County. Retrieved 2016-09-10.
5. Ganguly, Sinha and Adhikari, *Biology of Animal*, 2014-15
- 6. Hymen, Series of Arthropods, 2015-16**
7. Jerome C. Regier; Jeffrey W. Shultz; Andreas Zwick; April Hussey; Bernard Ball; Regina Wetzer; Joel W. Martin; Clifford W. Cunningham, 2010. "Arthropod relationships revealed by phylogenomic analysis of nuclear protein-coding sequences". *Nature*. 463 (7284): 1079–1083.
8. John G. Maisey & Maria da Gloria P. de Carvalho, 1995. "First records of fossil sergestid decapods and fossil brachyuran crab larvae (Arthropoda, Crustacea), with remarks on some supposed palaemonid fossils, from the Santana Formation (Aptian-Albian, NE Brazil)".
9. John J. McDermott, 1999. "The western Pacific brachyuran *Hemigrapsus sanguineus* (Grapsidae) in its new habitat along the Atlantic coast of the United States: feeding, cheliped morphology and growth".
10. Joachim T. Haug; Carolin Haug; Manfred Ehrlich, 2008. "First fossil stomatopod larva (Arthropoda: Crustacea) and a new way of documenting Solnhofen fossils (Upper Jurassic, 6-9).
11. Lipke B. Holthuis, 1991. "Introduction". *Marine Lobsters of the World*. FAO Species Catalogue, Volume 13. Food and Agriculture Organization, 1–2.
12. R.L. Kotpal, *Invertebrates Zoology Text Book*, 2016-17
13. Robert Gurney (1942). *Larvae of decapod crustacea*, London: Ray Society. pp. 1–306
14. Ruppert and Barnes, *Invertebrate Zoology*, 1994-1996

A Comparison Study on Nutritional and Health Status between Slum and Urban Housewives

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Abstract

In family needs in everyday life; housekeeping and maintaining the home; and making clothes for the family—and who is not employed outside the home. A housewife may also be called a *stay-at-home mother* or “SAHM”. In the present study a survey was conducted to compare health status between slum and urban areas housewife. The survey was carried out at Bhagwanpur-II block area, Purba Medinipur, West Bengal. The data was collected for slum areas housewife (n=15) and for urban areas housewife (n=15). A housewife is a woman whose occupation is running or managing her family’s home caring for her children; buying, cooking, and storing food for the family. The survey was found that different measurements like height, weight, blood pressure, pulse rate, waist and hip circumferences, body fat (from biceps, triceps by measuring skinfold thickness) were carried out. The participants were asked about their hygienic condition and diseases. It was found that there was no significant ($p>0.05$) differences in body mass index, systolic pressure, diastolic pressure, pulse pressure, pulse rate, triceps and biceps between slum and urban areas housewife. But it has noticed that waist hip ratio are significantly ($p<0.05$) lower in urban areas as compare to slum areas housewife. It was observed that more percentage of slum areas housewife were suffering from anemia, constipation, rashes, and peptic ulcer as compare to urban areas housewife. It was found that more percentage of urban areas housewife were hygienic is proper maintain from washing of hands after toilet and washing of cooking utensils compare to slum areas housewife.

Keywords: Slum areas housewife, urban areas housewife, Health, Comparison, Body mass index, Waist-hip ratio

1. Introduction

A housewife is a woman whose occupation is running or managing her family's home caring for her [children](#); buying, [cooking](#), and [storing](#) food for the family; buying [goods](#) that the family needs in everyday life; [housekeeping](#) and maintaining the home; and [making](#) clothes for the family—and who is not employed outside the home. A housewife may also be called a stay-at-home mother or “SAHM”, and a househusband may be called a “male homemaker”, “[stay-at-home father](#), or SAHD.

Webster's Dictionary describes a housewife as a married woman who is in charge of her [household](#). The British *Chambers's Twentieth Century Dictionary* (1901) defined a housewife as: “the mistress of a household; a female domestic manager; a pocket sewing kit”. (Kessler-Harris, 2003). A small sewing kit is sometimes called a “housewife” or “hussif” (Johnson *et al*, 2004).

A slum is a heavily populated urban [informal settlement](#) characterized by substandard housing and squalor (Nijman, J, 2010). While slums differ in size and other characteristics, most lack reliable sanitation services, supply of clean water, reliable electricity, [law enforcement](#) and other basic services. Slum residences vary from [shanty](#) houses to professionally built dwellings that because of poor-quality construction or provision of services have deteriorated into slums. (Ray and Suresh, 2016).

Causes include rapid rural-to-urban migration, economic stagnation and depression, high unemployment, poverty, informal economy, poor planning, politics, natural disasters and social conflicts. Strategies tried to reduce and transform slums in different countries, with varying degrees of success, include a combination of slum removal, slum relocation, slum upgrading, urban planning with citywide infrastructure development, and public housing. (Mona Serageldinet *al*, 2006).

An urban area is a [human settlement](#) with high [population density](#) and [infrastructure](#) of [built environment](#). Urban areas are [created](#) through [urbanization](#) and are categorized by [urban morphology](#) as [cities](#), [towns](#), [conurbations](#) or [suburbs](#). In [urbanism](#), the term contrasts to [rural areas](#) such as [villages](#) and [hamlets](#) and in [urban sociology](#) or [urban anthropology](#) it contrasts with [natural environment](#). The creation of early predecessors of urban areas during the [urban revolution](#) led to the creation of human [civilization](#) with modern [urban planning](#), which along with other human activities such as [exploitation of natural resources](#) leads to [human impact on the environment](#).

Unlike an urban area, a [metropolitan area](#) includes not only the urban area, but also [satellite](#) cities plus intervening rural land that is socio-economically connected to the core city, typically by [employment](#) ties through [commuting](#), with the urban core city being the primary labour market.

Bhupatinagar, Bhagwanpur –II Block area is a rural area having 180.20 sq.km areas and having population of 192,162. Cultivation is the main source of income of the people of this area. In this area people with all caste are living. For proper education several primary school, SSK, MSK, Jr. high School, High school, Higher secondary school two General College and B. Ed College are situated here. With the above information it

can be assumed that through Bhagwanpur-II Block area is situated in rural area but the area is developing very fast.

The objectives of the study survey can be made regarding the nutritional and health status of slum and urban areas housewife among people of whole Bhagwanpur-II block area.

2. Materials and method

In order to conduct the surveys satisfactorily, it is essential to have a well-accepted methodology. The present nutritional survey is carried out in the following procedure by using appropriate methods. The material and methodology adopted for the present study.

In this study 30 subjects (slum housewife -15, urban housewife -15) were selected at Madhakhali and Bayanda, PurbaMedinipur, West Bengal, India. The information was obtained by interviewing them.

Methods of assessment of nutritional status:

Height and weight was measured using anthropometric rod and Weight machine, respectively. All measurements were taken as per guideline of World Health Organization (WHO: 2016). Then the Body Mass Index (BMI) of women is calculated.

Personal History:

Back ground information about the respondents include age, education, religions, weight, height, socioeconomic status, father's and mother's occupation, number of total family member, number of earning member of family, dietary habit, habit of physical exercise are asked during this survey.

Anthropometric assessment:

Weight:

For weight measurement human weighing machine (BATHROOM WEIGHING SCALE, CROWN Classic, Ramon Surgical Company, Delhi) was used. Subjects stand on the platform of the machine with minimum clothes and exerting equal pressure on both feet.

Height:

For height measurement considered vertical distance from the floor to the vertex (maximum bulge of the top of the head) of the body while standing in stretched erect posture, feet together and firmly placed on the ground, weight equally distributed on both feet, looking straight and ahead, palm flat against side of the thigh. The height must be measured without shoes. The head should be comfortably held erect. For height measurement in the study anthropometric rod (Brand - DESCO, DELUXE SCIENTIFIC SURGICO PVT LTD, New Delhi) was used.

BMI :

BMI is a mathematical formula which correlates with the body fat of an individual. The BMI of each individual is calculated from the following formula.

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height}^2\text{m}} = \text{kg} / \text{m}^2$$

Classification of adult BMI according to WHO

Nutritional status	WHO Criteria BMI cut-off	“Asian criteria” BMI cut-off
Under weight	<18.5	<18.5
Normal	18.5-24.9	18.5-22.9
overweight	25-29.9	23-24.9
Pre-Obese	-	25-29.9
obese	≥30	≥30
Obese type 1 (obese)	30-40	30-40
obese type2 (morbid obese)	40.1-50	40.1-50
obese type3 (super obese)	>50	>50

(Llido, L.O. and Mirasol, R. 2011. **Comparison of Body Mass Index based nutritional status using WHO criteria versus “Asian” criteria: report from the Philippines.**)

Height and weight were measured using steel tape or anthropometric rod and Weight machine respectively. Then the BMI of woman is calculated. All measurements were taken as per guideline of World Health Organization .Mean and standard error is also calculated.

Waist circumference :

Horizontal circumference at the level of the greatest lateral indentation of trunk (i.e. at the level at which the belt is worn). Subject stood erect and abdomen relaxed during measurement.

Hip circumference:

Horizontal circumference at the level of the hip bone (or the level of the Glutens) was measured. During measurement subject stood erect and heels together.

Waist hip ratio:

It was measured from the ratio of waist circumference and hip circumference.

Waist hip ratio (WHR):

Anthropometric measurement from the ratio of waist circumference and hip circumference.

$$\text{WHR} = \frac{\text{Waist circumference (cm)}}{\text{Hip circumference (cm)}}$$

Blood pressure

Left arm blood pressure was taken with a sphygmomanometer (DOCTOR ANEROID SPHYGMOMANOMETER, S.S. SURGICAL CO., Delhi) and stethoscope (DOCTOR DX STETHOSCOPE, S.S. SURGICAL CO., Delhi) after the Participate has been seated in a relaxed position for 5 min. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were recorded to the nearest mm of Hg as the appearance (Phase I) and disappearance (Phase II) of karat off sounds, respectively.

Dietary assessment:

A diet survey provides information about dietary intake patterns of specific food consumed and estimated nutrient intakes. It indicates relative dietary inadequacies, which is helpful in planning health education activities and changes needed in the agriculture and food production industries. Most of the time, the surveys are carried out for 7 days. If needed, in different seasons survey can be repeated.

Statistical analysis of data:

The calculated data was analyzed by the mean value, Standard error and t- test.

The t-values are computed as follows:-

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S} \times \sqrt{\frac{n_1 n_2}{n_1 + n_2}} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

3. Result and discussion

There was no significant ($p > 0.05$) difference on BMI (kg/m^2) of slum and urban housewives (fig: 1). However Maya Laxmi Patel and Raywat Deonandan, (2017) found the increasing BMI of slum dwelling women is most significantly. In that study we hypothesized that no significance is BMI of slum and urban housewives. There was significant ($p < 0.05$) difference on Waist Hip Ratio of slum and urban housewives (fig: 2).

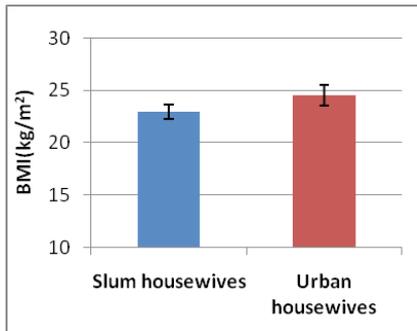


Figure1: Comparison of Body mass index (kg/m²) between slum and urban housewives. Vertical bars represent standard error of mean

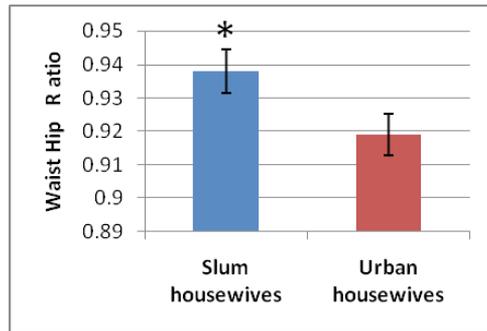


Figure2: Comparison of Waist Hip Ratio between slum and urban housewives. Vertical bars represent standard error of mean

There was significant ($p < 0.05$) difference on systolic blood pressure of slum and urban housewives (fig: 3). There was significant ($p < 0.05$) difference on diastolic blood pressure of slum and urban housewives (fig: 4).

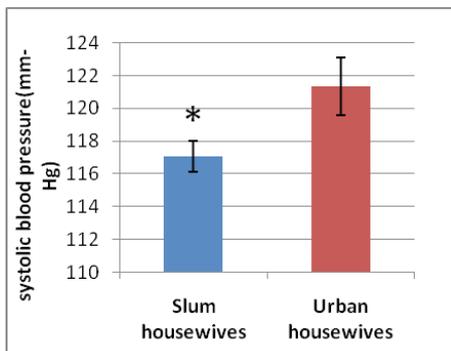


Figure 3: Comparison of Systolic Blood Pressure (mm-Hg) between slum and urban housewives. Vertical bars represent standard error of mean

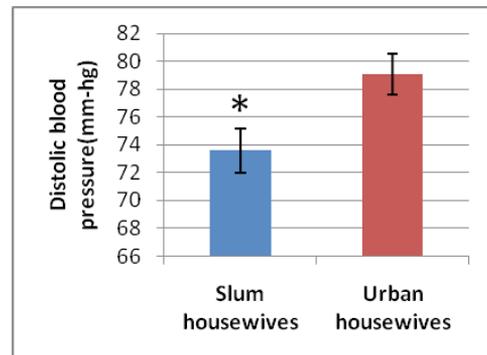


Figure 4: Comparison of Diastolic Blood Pressure (mm-Hg) between slum and urban housewives. Vertical bars represent standard error of mean

There was no significant ($p > 0.05$) difference on pulse rate of slum and urban housewives (fig: 5). There was no significant ($p > 0.05$) difference on pulse pressure of slum and urban housewives (fig: 6).

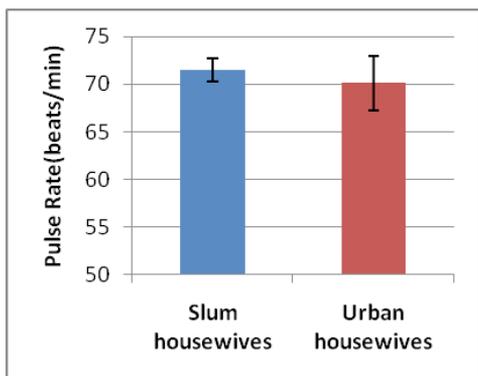


Figure 5: Comparison of Pulse rate (beats/min) between slum and urban housewives. Vertical bars represent standard error of mean

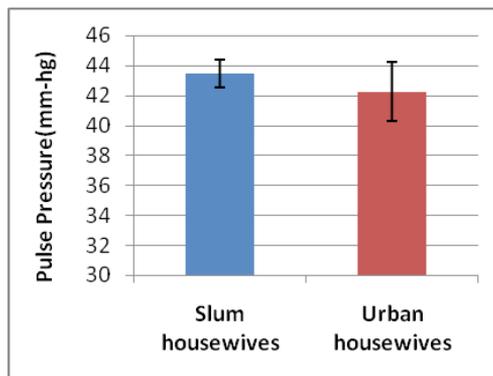


Figure 6: Comparison of Pulse Pressure (mm-Hg) between slum and urban housewives. Vertical bars represent standard error of mean

There was no significant ($p > 0.05$) difference on biceps of slum and urban housewives (fig: 7). There was no significant ($p > 0.05$) difference on triceps of slum and urban housewives (fig: 8).

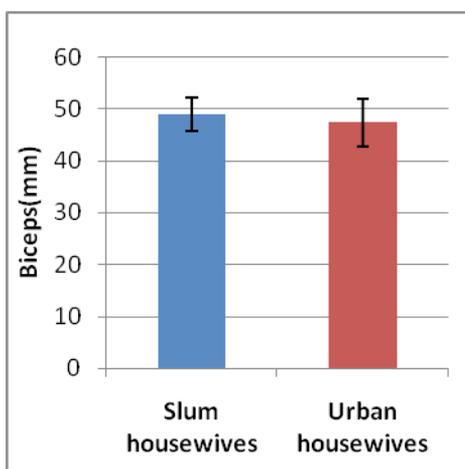


Figure 7: Comparison of Biceps (mm) between slum and urban areas housewives. Vertical bars represent standard error of mean

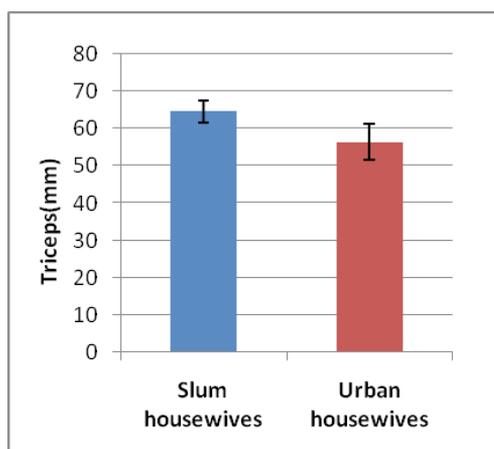


Figure 8: Comparison of Triceps (mm) between slum and urban housewives. Vertical bars represent standard error of mean

Table 1: Anthropometric measurement of Slum and Urban housewives.

Anthropometric indices	Slum housewives (Mean \pm SEM)	Urban housewives (Mean \pm SEM)	t value	Significance
BMI (kg / m ²)	22.95 \pm 0.697	24.55 \pm 1.00	1.31	Not significant
Waist Hip Ratio.	0.938 \pm 0.0065	0.919 \pm 0.0063	2.283	Significant

Pulse Rate (beats/min).	71.53±1.195	70.13±1.47	2.145	Significant
Systolic Pressure (mm-Hg)	117.066±0.968	121.33±1.76	2.527	Significant
Diastolic Pressure (mmHg)	73.6±1.59	79.06±1.47	0.544	Not significant
Pulse Pressure(mm-Hg)	43.46 ± 0.960	42.26 ± 1.98	0.457	Not significant
Biceps	48.93 ±3.23	47.33 ± 4.52	0.288	Not significant
Triceps	64.6 ±2.89	56.4 ± 4.92	1.459	Not significant

There was no significant ($p>0.05$) difference on protein of slum and urban housewives (fig: 9). There was significant ($p<0.05$) difference on fat of slum and urban housewives (fig: 10).

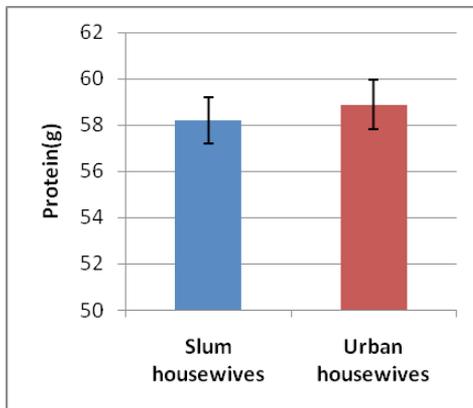


Figure 9: Comparison of protein (g) between slum and urban housewives. Vertical bars represent standard error of mean

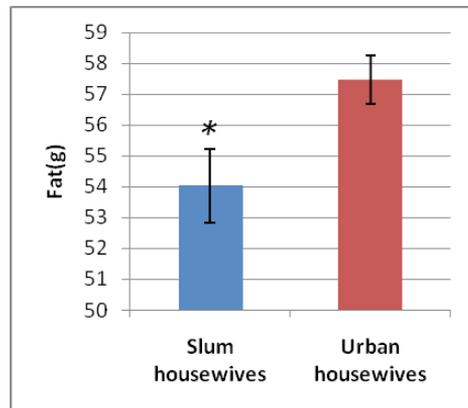


Figure 10: Comparison of fat (g) between slum and urban housewives. Vertical bars represent standard error of mean

There was no significant ($p>0.05$) difference on carbohydrate of slum and urban housewives (fig: 11). There was no significant ($p>0.05$) difference on energy of slum and urban housewives (fig: 12). Violet Jayamani et al,(2013) said that the odds of the rural women engaging in high physical activity are greater than urban women . The odds of the urban women consuming a high calorie diet are greater than the rural women. The odds of the urban women being overweight/ obese are than that of the urban women. Women who were housewives and not doing household work were significantly less physically active, took higher calorie diet, and were more overweight and obese compared to women who were involved in active household work.

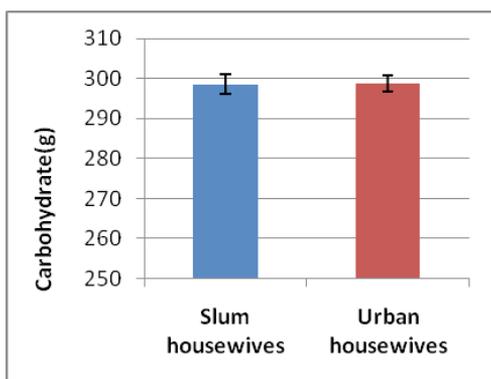


Figure 11: Comparison of carbohydrate (g) between slum and urban housewives. Vertical bars represent standard error of mean

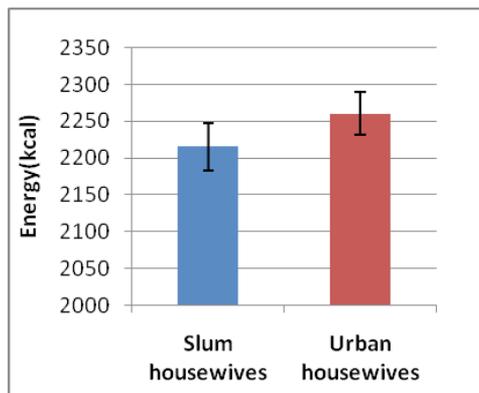


Figure 12: Comparison of energy (kcal) between slum and urban housewives. Vertical bars represent standard error of mean

There was no significant ($p>0.05$) difference on calcium of slum and urban housewives (fig: 13). There was no significant ($p>0.05$) difference on iron of slum and urban housewives (fig: 14).

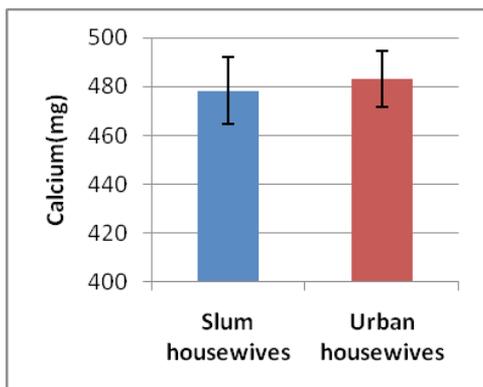


Figure 13: Comparison of calcium (mg) between slum and urban housewives. Vertical bars represent standard error of mean

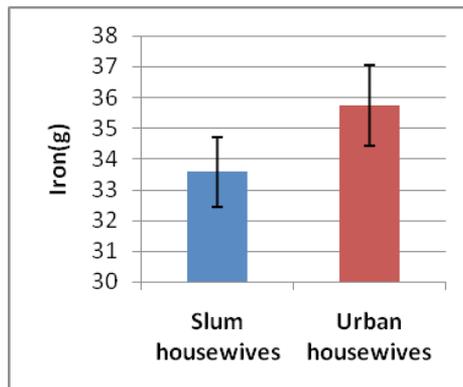


Figure 14: Comparison of iron (g) between slum and urban housewives. Vertical bars represent standard error of mean

There was no significant ($p>0.05$) difference on niacin of slum and urban housewives (fig: 15). There was no significant ($p>0.05$) difference on folic acid of slum and urban housewives (fig: 16).

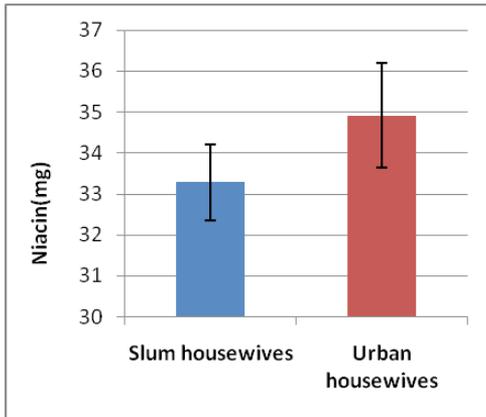


Figure 15: comparison of niacin (mg) between slum and urban housewives. Vertical bars represent standard error of mean

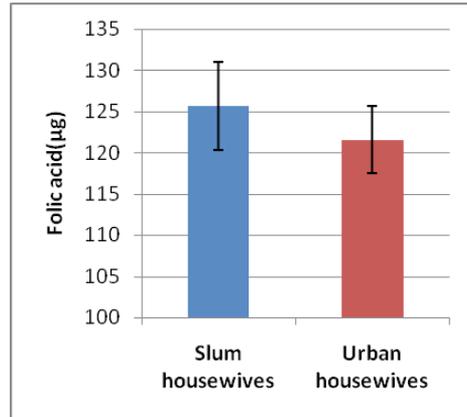


Figure 16: Comparison of folic acid (µg) between slum and urban housewives. Vertical bars represent standard error of mean

Table 2: Dietary assessment and analysis of Slum and Urban housewives.

Nutrient	Slum housewives (Mean ±SEM)	Urban housewives (Mean ±SEM)	t value	Significance
Protein (g)	58.196 ± 0.99	58.87 ± 1.07	0.461	Not significant
Fat (g)	54.026 ± 1.18	57.48 ± 0.79	2.426	Significant
Carbohydrate (g)	298.527 ± 2.43	298.764 ± 2.024	0.075	Not significant
Energy (kcal)	2215.66 ± 32.28	2260.436 ± 28.80	1.00	Not significant
Folic acid (µg)	125.662 ± 5.30	121.574 ± 4.029	0.614	Not significant
Calcium (mg)	478.234 ± 13.754	483.32 ± 11.48	0.284	Not significant
Iron (mg)	33.578 ± 1.140	35.75 ± 1.31	1.26	Not significant
Niacin (mg)	33.29 ± 0.93	34.91 ± 1.28	1.018	Not significant

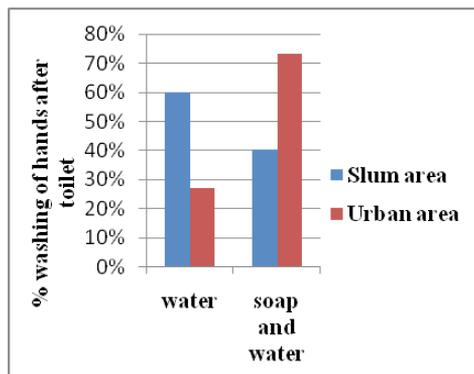
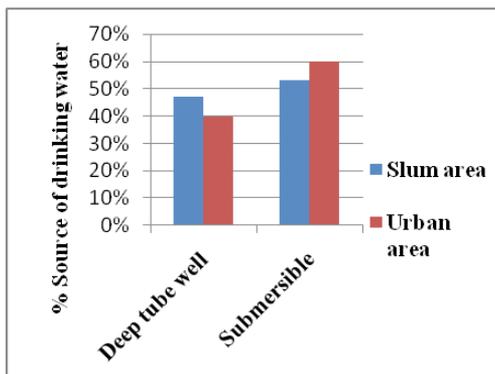


Figure 17: comparison of source of drinking water between slum and urban housewives. Vertical bars represent standard error of mean

Figure 18: comparison of washing of hands after toilet between slum and urban housewives. Vertical bars represent standard error of mean

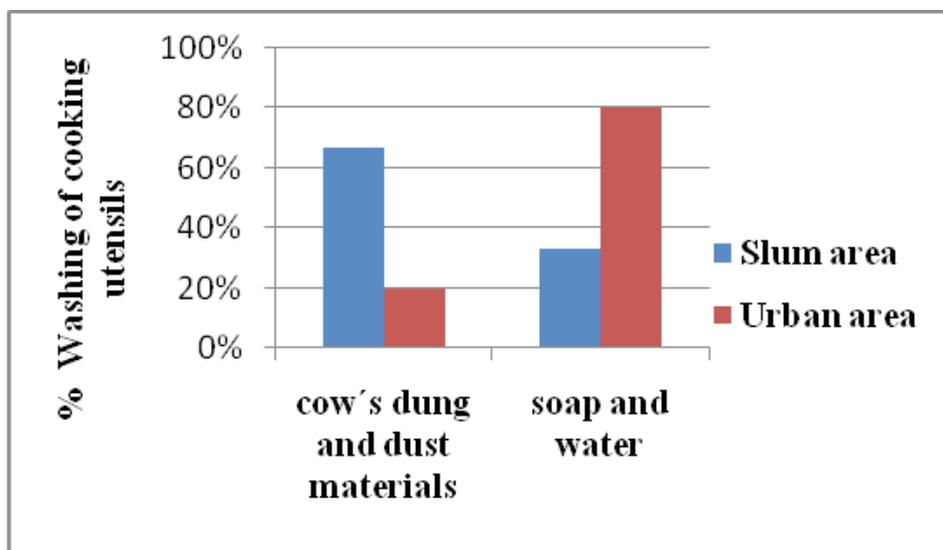


Figure 19: comparison of washing of cooking utensils between slum and urban housewives. Vertical bars represent standard error of mean

Table 3: Tabular representation of hygienic condition of Slum and urban housewives

Hygienic condition	Slum housewives (%)	Urban housewives (%)
Source of drinking water		
Deep tube well	47	40
Submersible	53	60
Washing of hands after toilet		
1. Water only	60	27
2. Soap and water	40	73

Washing of cooking utensils	67	20
1.Cow dung ash	33	80
2.Soap and water		

From the survey it was found that among slum housewives 27% of anaemia, 40% of constipation and urban housewives 13% of anaemia, 33% of constipation disease suffering. From the survey it was observed that among slum housewives and urban housewives both is 47% suffering from menstruation problem and the survey it was found that among 33 % of slum housewives and 20% of urban housewives suffering from hypertension. From the survey it was found that among 20% of slum housewives and 13% of urban housewives suffering from diabetes. From the survey it was noticed that among 40% of slum housewives and 7% of urban housewives suffering from rashes.

Lack of physical cleanliness, unhygienic living and personal attention widespread skin disease found among the different women age groups in the study area. About 14% of the respondent women mentioned about various types of chronic skin diseases. According to Haimchar Upazila Health Complex, more than 80% aged women are suffering from various skin diseases. The problem found very acute in the mid aged women. Some of the respondent mentioned that not only herself, their other family members are also suffering from this contagious disease. Poor sanitation, lack of cleanliness and proper bathing and clothing practices, living in crowd and poor ventilated houses, using unsafe and dirty water for bathing, washing clothes, washing utensils etc. may be the prime causes of wide spread women skin diseases in the study area

From the survey it was observed that among slum housewives and urban housewives both is 27% suffering from eczema. The survey it was noticed that among 20% of slum housewives and 7% of urban housewives suffering from peptic ulcer. From the survey it was noticed that among 47% of slum housewives and 20% of urban housewives suffering from gastrointestinal disorder. Alak Paul *et al.*, (2014) the low health status and health problems of women in the rural char areas of Chandpur district are the consequences of a number of social and environmental factors which have brought to light from the study. From the discussion with the focus group the factors identified as extreme poverty, lack of education and awareness, some backward social practices or misconceptions, negligence to women etc. The women in the study area found overburdened with work, tired, most are anemic and lack of personal attention about health and health care. Besides, extreme poverty does not allow themselves to facilitate with disease diagnose, better treatment and having medicine. Thus diseases become chronic and they are to survive by hiding the diseases or with the diseases. From the field observation, it was realized that early marriage, repeated child bearing, needs are often been ignored by the family head and social leaders. Ignorance, poverty and manual labor all have deleterious effects on women health in the remote rural char areas of Chandpur district. It is also clear from the study that women's health and their special

Table 4: Percentage of Slum and Urban housewives suffering in different diseases and symptoms

Disease	Slum areas housewife %	Urban areas housewife %
Anemia	27	13
Constipation	40	33
Menstruation	47	47
Hypertension	33	20
Diabetes	20	13
Rashes	40	7
Eczema	27	27
Peptic ulcer	20	7
Gastrointestinal disorder	47	20

4. Summary and conclusion

In this study survey was on made on status of Slum and Urban housewives at Bhupatinagar(Bhagwanpur II Block area).

Summary:

1. There was no difference of BMI, Pulse pressure, Pulse rate, Biceps, Triceps in Slum and Urban housewives.
2. There was difference of WHR, Systolic pressure, Diastolic pressure in Slum and Urban housewives.
3. Slum housewives are suffering more in anemia, constipation, hypertension, diabetes, rashes, peptic ulcer, gastrointestinal disorder compare to urban housewives.
4. Both slum housewives and urban housewives were suffering from menstruation problem and eczema equally.
5. Both slum and urban area housewives were more drinking water from submersible compare to deep tube well.
6. Slum housewives were more used of soap and less use of soap and water then urban housewives in washing of hands after toilet.
7. Slum housewives were more used of soap and less use of soap and water then urban housewives in washing of cooking utensils
8. There was no significant difference in protein, carbohydrate, energy, folic acid, calcium, iron, niacin intake among slum and urban housewives.
9. There was significant difference in fat intake among slum and urban housewives.

Conclusion

Many of the women in the urban slums are born in to the slums and as such, live in an environment where this is all that they know. However, there still remains a high degree of what prevailed traditionally with regards to the cooperation and social unity, even in the face of high degrees of urbanization. In this paper, the researcher posited the hypothesis that:

“The Indian people are generally of Gemeinschaft nature and, feel most comfortable in this state. As such, they will have a tendency to, either revert back to this state or, try as much to mimic such a state, even in a Gesellschaft environment”.

This study shows that these slum-dwelling women’s diets lack adequate micronutrient-rich foods. Standard of living and education may have an impact on dietary choice and nutrition status, therefore it is important that any interventions aimed at changing women’s dietary behavior are targeted to the setting in which the woman lives and take into account the availability, cost and other factors which may affect whether she is able to consume a particular food.

The concept of “women as women”, responsible for their own health and welfare, needs to be advertised within nutrition programmers. The concept of improving women’s nutrition for their own sakes, rather than just as mothers, needs to be fostered. There is little doubt that a woman whose basic nutritional and health needs are met will be in a better position to meet the needs of her family.

References

1. Alak Paul, Md. Mahbub Murshed and Samia Akther (2014), Women Health And Disease Pattern In The Rural Areas Of Bangladesh: A Case Study On Haimchar Upazila Under Chandpur District. Department of Geography and Environmental Studies J. Asiat. Soc. Bangladesh, Sci. **40(1)**: 27-37.
2. Alsharif, N. Z., Lawson, T., & Stohs, S. J. (1994). Oxidative stress induced by 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin is mediated by the aryl hydrocarbon (Ah) receptor complex. *Toxicology*, **92(1-3)**: 39-51.
3. Benin, M. H., & Agostinelli, J. (1988). Husbands’ and wives’ satisfaction with the division of labor. *Journal of Marriage and the Family*, 349-361.
4. Besl, P. J., & Jain, R. C. (1985). Three-dimensional object recognition. *ACM Computing Surveys (CSUR)*, **17(1)**: 75-145.
5. Biernat, M., & Wortman, C. B. (1991). Sharing of home responsibilities between professionally employed women and their husbands. *Journal of personality and social psychology*, **60(6)**: 844.
6. Broman, C. L., Neighbors, H. W., & Jackson, J. S. (1988). Racial group identification among Black adults. *Social Forces*, **67(1)**: 146-158.
7. Bulanda, R. E. (2004). Paternal involvement with children: The influence of gender ideologies. *Journal of Marriage and Family*, **66(1)**: 40-45.
8. Dafni, A. (2007). Rituals, ceremonies and customs related to sacred trees with a special reference to the Middle East. *Journal of Ethnobiology and Ethnomedicine*, **3(1)**: 28.

9. Dube, S. C. (1963). Men's and women's roles in India: A sociological review. *Women in New Asia*. Ed. by Barbara E. Ward, 174-203.
10. Haavio-Mannila, E., Kontula, O., & Mäkinen, M. (2003). *Sexual trends in the Baltic Sea area*. Helsinki: Population Research Institute, Family Federation of Finland.
11. Hinz, K., Schlüter, H. U., Grant, A. C., Srivastava, S. P., Umpleby, D., & Woodside, J. (1979). Geophysical transects of the Labrador Sea: Labrador to southwest Greenland. *Tectonophysics*, 59(1-4), 151-183.
12. Johnson, L., & Lloyd, J. (2004). Sentenced to everyday life: Feminism and the housewife.
13. Kessler-Harris, Alice (2003). *A history of wage-earning women in the United States*. Oxford University Press,
14. Kluwer, E. S., Heesink, J. A., & Van de Vliert, E. (1996). Marital conflict about the division of household labor and paid work. *Journal of Marriage and the Family*, 958-969.
15. Kluwer, E. S., Heesink, J. A., & Van de Vliert, E. (1996). Marital conflict about the division of household labor and paid work. *Journal of Marriage and the Family*, 958-969.
16. Konsler, T. R., Zito, S. W., Shelton, J. E., & Staba, E. J. (1990). Lime and phosphorus effects on American ginseng: II. Root and leaf ginsenoside content and their relationship. *Journal of the American Society for Horticultural Science*, 115(4): 575-580.
17. Lye, D. N., & Biblarz, T. J. (1993). The effects of attitudes toward family life and gender roles on marital satisfaction. *Journal of Family Issues*, 14(2): 157-188.
18. Mederer, H. J. (1993). Division of labor in two-earner homes: Task accomplishment versus household management as critical variables in perceptions about family work. *Journal of Marriage and the Family*, 133-145.
19. Mills, Dorothy Jane (2004). *A Woman's Work: Writing Baseball History with Harold Seymour*. McFarland,
20. Mona Serageldin, Elda Solloso, and Luis Valenzuela,(2006). Local Government Actions to Reduce Poverty and Achieve The Millennium Development Goals,Global Urban Development Magazine, 2:40-49.
21. Nijman, J. (2010). A study of space in Mumbai's slums. *Tijdschrift voor economische en sociale geografie*, 101(1), 4-17.
22. Patrick, D. L., & Erickson, P. (1993). Health status and health policy: quality of life in health care evaluation and resource allocation.
23. Pillay, P., & Krishnan, R. (1989). Modeling, simulation, and analysis of permanent-magnet motor drives. I. The permanent-magnet synchronous motor drive. *IEEE Transactions on industry applications*, 25(2): 265-273.
24. Raghuram, T. C., Sharma, R. D., Sivakumar, B., & Sahay, B. K. (1994). Effect of fenugreek seeds on intravenous glucose disposition in non-insulin dependent diabetic patients. *Phytotherapy Research*, 8(2): 83-86.
25. Ray, Suresh. (2016). "Socio demographic conditions & morbidity status of urban slum dwellers in Pune city." *International Journal of Multidisciplinary Research and Development* 3.6: 65-68.
26. Roberson Jr, D. N. (2003). Learning experiences of senior travellers. *Studies in Continuing Education*, 25(1): 125-144.
27. Srivastava, S. P. (1978). Evolution of the Labrador Sea and its bearing on the early evolution of the North Atlantic. *Geophysical Journal International*, 52(2): 313-357.

28. Stremmel, W., Strohmeyer, G., Borchard, F., Kochwa, S., & Berk, P. D. (1985). Isolation and partial characterization of a fatty acid binding protein in rat liver plasma membranes. *Proceedings of the National Academy of Sciences*, **82(1)**: 4-8.
29. [Violet Jayamani](#), [Vijayaprasad Gopichandran](#),¹ [Premila Lee](#),² [Greeda Alexander](#),² [Solomon Christopher](#),³ and [Jasmin Helan Prasad](#) (2013). Diet and Physical Activity Among Women in Urban and Rural Areas in South India: A Community Based Comparative Survey *Journal of family medicine and primary care*. **2(4)**: 334–338.

Echinodermata Larva, Their Distribution, Habits, Characters and Phylogeny

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Abstract

Larval development of different echinoderms are reviewed. For each class, the various larval types, common features of them, larval developmental patterns in terms of life-cycle character states and sequences of larval stages, phylogenetic distribution of these traits, and evolutionary transitions are described here. Asteroids, echinoids, holothuroids, and ophiuroids, but not crinoids, have feeding larvae. Direct development has been documented in asteroids, echinoids, and ophiuroids. From this review, it may be concluded that it is the ecological and functional demands on larvae which impose limits on developmental evolution and determine the associations of larval types and life-cycle character states that give rise to the developmental patterns that are observed in echinoderms. But there are two factors which limit analyses of larval and life-cycle evolution in echinoderms. First is the limited understanding of developmental diversity and lack of good phylogenies.

Keywords: Echinodermata, larva, phylogeny, evolution, development

1. Introduction

The echinoderms or the “spiny skinned” animals are a unique group of radially symmetrical headless, brainless, slow moving, marine animals of very ancient origin. They constitute a considerable proportion of the animal life of the seashores. The echinoderms most commonly known even to the those who have never been to sea beach, are the starfish or seastars which have become virtually symbol of sea life. Other forms, such as brittle stars, sea urchins, sea cucumbers and sea lilies are also known as seashore visitors (1).

Echinoderms are unisexual animals. Sexual dimorphism is absent. Fertilization takes place in water. The development may be direct or indirect. If the development is indirect it includes larva stages. In different classes of echinoderms, different types of larvae complete the development (2). The larval form is bilaterally symmetrical. It undergoes metamorphosis and radial symmetrical adult is developed.

Table. 1: Classes of phylum echinodermata & their larval forms

Classes	Larval forms
1. Asterozoa	Bipinnaria & Brachiolaria
2. Ophiurozoa	Ophiopluteus
3. Echinozoa	Echinopluteus
4. Holothurozoa	Auricularia, doliolaria
5. Crinozoa	Doliolaria & Pentacrinoid

2. Asterozoa

More than 1000 different species of asterozoans commonly known as sea stars are distributed in all the oceans and at all depths. They differ in certain details but as a class they are more similar in structures and habits. The genus *Asterias* comprises of nearly 150 species, of which the chief ones are *A. rubens* on the English and the north European coasts, *A. vulgaris* are distributed north atlantic coast of North America, *A. forbesi* at the eastern seashore from the maine to the Gulf of Mexico, and *A. amurensis* at the Behring Sea, Japan and Korea north-ward. The sea stars are exclusively marine animals (1). They live in shallow water to very great depths, on the floor of the sea bottom by their tube feet. They are found more abundantly on the hard rocky or shallow bottoms where locomotion and concealment are easier, rather than on the soft sandy or muddy bottoms where they can make only little progress. Sea stars, which live on the bottom, are known as benthonic. While most species are negative to light, seeking shaded areas, some including *Asterias rubens* are strongly positive to light. They usually remain quiet in the daytime. Its larval form is known as bipinnaria larva (1). It is a bilaterally symmetrical free swimming pelagic larva. The pre-oral region is elongated. Post-oral region is broad. The anterior end forms pre-oral lobe. The ciliated band at the pre-oral lobe forms into 2 separate bands, Pre-oral band of cilia, and post oral band of cilia. This larva slowly grows into the next larval form called Brachiolaria larva.

2. Larval development of bipinnaria larva

The gastrula elongates in length and it gives rise to Bipinnaria larva. Asterozoa have two types of development. The direct type has, yolky eggs and no free swimming stage. The indirect type has holothalial eggs with little yolk and a free swimming larval stage. The egg hatches into a larva which develops silia and begins a free swimming life (3). The elementary canal is formed and the larva feeds on diatoms etc. the stomodaeum

wall contains a powerful ciliary band which helps in feeding. The uniform ciliation becomes confined to two lateral longitudinal locomotory ciliated bands characteristic of eleutherozoan larvae. The two lateral bands connect in front of the mouth as a preoral loop and in front of the anus as a preanal loop (2). The preoral loop later separates or rings around the body. The larva also develops three lateral lobes or projections on each side of the body bordered by ciliary bands (Fig. 1).

3. Internal development of bipinnaria larva

The tip of larval archenteron gives rise to mesenchyme and later gives rise to two lateral pouches which connect anteriorly to form a U-shaped coelom. The posterior ends of the lateral pouches become pinched off to form the right and left somatocoels (4). The remaining anterior portions represent the hydrocoel and axocoel, but they never separate. The left hydrocoel connects with the dorsal surface to form the hydropore, without ectodermal invagination. Ventrally an ectodermal invagination meets the archenteron and the larval alimentary tract is distinguished into mouth, oesophagus, stomach and intestine (3). Blastopore remains as larval anus. The right somatocoel and axohydrocoel are reduced in metamorphosis, while the left axohydrocoel gives rise to water ring and radial canals. The madreporite or dorsal sac may originate either from rearrangement of mesenchyme cells or from ectodermal invagination or from right axohydrocoel. Phylogenetically it may be regarded to represent right axohydrocoel, as in echinoids. The bipinnaria larva, after a few weeks of free swimming existence, changes to larval stage, called brachiolaria larva (Fig. 1).

4. Brachiolaria larva

As bipinnaria transforms into brachiolaria larva by addition of three short arms at the preoral lobe, known as brachiolar arms. One arm is median and two lateral. The brachiolar arms contain coelomic extensions and adhesive cells at their tips (4). At their base is an adhesive glandular area acting as a sucker. The appearance of sucker marks the beginning of metamorphosis (Fig. 1). This larva after swimming few settles on a solid object and gets attached to it by its adhesive arms. Posterior end of the larva enlarges and lifts to the right-side.

5. Metamorphosis

The brachiolaria larva attaches to some object by its adhesive structures. The when the larva anterior region acts as a stalk, while the posterior part, having gut and coelomic chambers. Converts into a young star, detaches itself and begins to lead a free life. In many species the development is shortened by deletion of some larval stages. In astropectan the brachiolaria larva is omitted and the bipinnaria larva directly metamorphoses into the adult in 2 to 3 months (5). In *Asterina gibbosa*, the bipinnaria larva is omitted, the larva develops an adhesive apparatus, homologous to brachiolar arms and sucker, and undergoes metamorphosis (6). In *Luidia* a giant and peculiar larva is formed known as bipinnaria asterigera, which has a long slender anterior region having two broad arms, while remaining arms are found around posterior part which develops into the baby star (Fig. 3).

6. Ophiuroidea

The ophiuroidea form the most numerous class of living echinoderms. They are found in all seas, at all types of bottom and at all depths from the intertidal zones to 6000 meters deep. They are small in size, secluded in habits and rather difficult to collect, but they have spread every where and adapted themselves to wide range of conditions. Some widely distributed and extremely common types are *Amphipholts squamata*, and *Ophiactis savignyi* (5, 6).

The ophiuroids are the most lively and active of all echinoderms. Though most common animals of the littoral fauna, they invite little attention due to their small size and retiring habits, so that they are not conspicuous as the sea stars they are negative to light. During day, they remain concealed under stones and shells, among seaweeds, coral colonies and other ranching coelenterates, in interstices of sponges, in available nooks and crevices, or buried in bottom sand or mud, to become active and night. If the stone is over turned, the serpent stars quickly scurry beneath it again. Movement is not effected by tube feet, as in star-fish. They move rather by rapid, snake-like muscular jerks of the sinuous arms (4, 5). The arms are highly flexible because of the articulating joints or segments of which they are chiefly composed. They bend and coil rapidly, pulling and pushing the body at considerable speed. During locomotion, the disc is held above the substrate. The long, flexible arms are well adapted for holding to objects and for swimming. Carnivorous in diet, they feed on small animals, such as crustaceans, molluscs, worms and others along with organic debris. (Fig. 1)

7. Ophiopluteus larva

This larva is seen in the life history of ophiuroidea (Brittle star). It shows many long arms. It is bilaterally symmetrical. It is transparent Pelagic. The arms are supported by calcareous rods. The arms are directed upwards. Preoral loop is reduced. Ciliated band is undivided. The posterolateral arms are very long and they are directed forwards. The digestive system is developed. It opens with mouth and ends with anus. This larva swims for some time before undergoing metamorphosis (1, 3).

In brittle stars, the free swimming larva is a pluteus and is known as ophiopluteus, which is similar to the echinopluteus of echinoids. However, ophiopluteus has fewer arms than the echinopluteus. The posterolateral arms are the longest directed forwards. After gastrulation, the embryo gives off arms which are formed gradually (6). The posterolateral arms are formed first. After 4, 10 and 18 days, anterolateral arms, postoral arms and posterodorsal arms develop respectively. The ciliated bands accompany the arms edges internally the larva contains coelomic chambers and archenteron, The internal development follows the same pattern as in other classes. The larvae begins metamorphosis, while still free swimming, and there is no attachment stage. The tiny serpent star sinks to the bottom to begin its adult existence (5). In viviparous forms, as *Amphiura vivipara*, the pluteus stage is omitted. In *Ophionotus hexactis*, the development takes place in ovary and the aborted pluteus larva is devoid of arms and anus (Fig. 1).

8. Echinoidea

The echinoids are exclusively marine, benthonic animals. They inhabit all seas and all sorts of bottom, from intertidal zone to depths up to 5000 meters but are particularly abundant in the coastal waters. They live on partially rocky or other types of hard bottoms, such as the coral reefs, all though they may be found on sand. They are gregarious, and frequently occur in sheltered tide pools in such vast numbers that their spines touch and it is impossible to step between them. Many rock boring urchins hollow out excavations in rocks in which they live by their teeth, or by absorption of calcareous and non calcareous materials (4, 6). They move slowly about by means of their podia or spines or by both they keep oral surface in contact with the substratum and if turned over, are generally able to right themselves. They feed on sea weeds, small and sluggish creatures, as well as sessile and encrusting organisms, such as barnacles, bryozoans, hydroids, sponges, polychaete worms, etc. In fact, they act as general scavengers eating all sorts of organic substances on the sea bottom (Fig. 1). Many ciliate commensals and other parasites live in their digestive tract and in or their bodies. Among their chief enemies are the fish, stars, crabs, predaceous birds and mammals

9. Echinopluteus larva

After gastrulation, *echinopluteus* larva is formed. The gastrula stage becomes conical in shape. One side becomes flattened and forms the oral surface. The stomodaeal invagination communicates with archenteron and the gut is differentiated into mouth, oesophagus, stomach and intestine. Blastopore remains as larval anus (7). The larva begins to form projections which develop into arms. The arms may be named as preoral anterolateral, anterodorsal, postoral, posterodorsal and postrolateral. The postrolateral arms are very short and directed outwards or backwards. In some cases, the anterodorsal arms may also not appear. Thus, a fully developed echinopluteus may have only 5 or even 4 pairs of arms, instead of the usual 6 pairs. These arms have pigmented tips and are supported by calcareous skeletal rods which originate from spicules secreted by mesenchyme (6, 7). The skeletal rods may be simple or thorny or fenestrated or branched and are of classificatory importance for different species. The locomotion is by ciliated bands. Which in some cases become thickened and known as *epeuleters*. In *Arbacia* and *Cidaris*, the echinopluteus develops special ciliated lobes, between the arm bases which are known as vibratile lobes, auricular lobes or auricles.

Internally, the archenteron gives off hydro-enterocoels which contribute to axocoels, hydrocoels and somatocoels. An ectodermal invagination takes place on the left side which enlarges and forms a vestibule. The hydrocoels and vestibule form the oral side of the adult. The hydrocoel gives off five radial canals and five primary podia (Fig. 1). The lantern is formed from left somatocoel. The *Echinopluteus* larva is microscopic, free-swimming in water and it develops within 7 to 30 days. Metamorphosis is extremely rapid, taking place in about an hour. There is no attachment stage as in asteroids.

10. Holothuroidea

Holothurians are widely distributed at present through all seas. They are found at all depths from shallow to very deep water, and are primarily of benthonic and sluggish

habits. Some in rocky crevices and crannies and among corals and seaweeds, but the majority are found on sandy bottoms, either fully exposed or wholly or partially buried in mud. When disturbed, they contract slowly. Some holothurians are plankton feeders, securing minute living plants and animals by means of their tentacles (4, 6). Others feed on organic particles from the sand which is pushed into the mouth. They move slowly by using tube feet or by muscular movements of the body. In the Indo-Pacific, a little commensal pearlfish, *Carapus*, lives in the base of the respiratory tree of sea cucumber for shelter. To enter its home, the fish nudges the anus of the sea cucumber with its snout and then backs in, tail first (Fig. 1). The fish has reduced scales, no pelvic fins, and an anteriorly shifted anus. But only a few cucumbers have such commensals. *Cucumaria* is a cosmopolitan genus including about 72 species. It is relatively sedentary and excavates a temporary U-shaped burrow, from which the oral end of the animal projects to the surface (7, 8).

11. Auricularia larva

After gastrulation and formation of coelomic sacs and gut, the embryo becomes a free swimming larva known as *auricularia* larva. It develops in 3 days. The *auricularia* larva is a transparent organism with pelagic habits and measuring 0.5 to 1 mm. in length. It swims by a ciliated band, which continues around the mouth forming a *preoral loop*, and around the anus to form an anal loop (4, 6). Internally, the larva contains a curved gut with sac-like stomach, hydrocoel and right and left somatocoels. The hydrocoel becomes lobulated forming primary tentacles, and communicates with hydropore by a canal. Some giant *auricularians* of unknown adults have been reported from Bermuda, Japan and Canary islands. They measure about 15 mm. in length and possess a frilly flagellated band (1, 3).

12. Doliolaria larva

The *auricularia* larva soon changes to barrel shaped form called *doliolaria* of crinoids. In *doliolaria* stage, the continuous ciliated bands are broken into 3 to 5 flagellated rings. The mouth has shifted to the anterior pole and the anus to the posterior pole (5, 6). In its gradual metamorphosis, it acquires 5 tentacles and 1 to 2 functional podia and is sometimes referred to as a *pentaculata*. Additional podia and tentacles appear later. Eventually the young sea cucumber settles to the bottom and assumes the adult mode of life.

In *Cucumaria planici* and *C. quinquesemita*, etc., the *auricularia* stage is omitted, and the embryo directly develops into a *doliolaria larva*. In *Cucumaria saxicola*, *C. frondosa* and *Psolus phantapus*, both *auricularia* and *doliolaria* stages are omitted and the larva simply swims about having an oval ciliated shape. In *Holothuria floridona*, the embryo hatches directly into young or juvenile (Fig. 1).

13. Crinoidea

Crinoids occur in nearly all oceans, ranging from shallow waters to great depths, but they are particularly abundant in the Indo-Pacific region or East Indian waters. The

best known genus *Antedon* includes seven species represented in the littoral zones of Western Europe, Western Africa, Mediterranean and tropical America. Sea-lilies are quite abundant but seldom seen being inhabitants of deep seas where man cannot venture. In their dark, deep recesses, the water pressure is so great that any person reaching there would instantly be crushed. Sea-feathers occur at moderate depth, among rocks and coral colonies and very few occur on sandy or muddy bottoms. Normally they remain inactive, clinging to substratum by means of grappling cirri, and look somewhat plant-like in external appearance. They can move about slowly, creeping by means of cirri, or swim gracefully by bending and straightening their arms (4, 7).

Crinoids are gregarious animals, often forming very dense population or "gardens", resulting probably due to slight amount of dispersal afforded by larvae which are feeble swimmers. In some localities off Scandinavia, the bottom is completely covered with *Antedon petasus*. Their arms remain extended widely to collect microscopic animals, and plants which serve as food. Autotomy and regeneration of arms and quite common. Even the lost visceral mass may be regenerated completely within a few weeks. It has been suggested that the occasional expulsion of viscera frees the crinoids from parasite (Fig. 1).

14. Pentacrinoid larva

This larval stage is also present in crinoids. It is the second larval stage of crinoids. The anterior end of the antedon larva, after attachment, is prolonged into an elongated narrow stalk and the free end becomes broader. The ciliated depression becomes a closed ectodermal vesicle which is gradually shifted to the free end. The floor of the depression is perforated by mouth and with the disappearance of the roof, the mouth and the tentacles become exposed. This particular phase is called cystidean or pentacrinoid stage (1, 6). This stage resembles closely the adult pentacrinus. The stalk in this form develops from the pre-oral lobe. This stage is quite similar to that of Asterozoa excepting that it lacks circumoral vessel (Fig. 1).

15. Significance of Echinoderm larvae:

After detailed discussion on various larvae of echinoderms, it has been seen that the different classes of echinoderms have somewhat different larvae that go by different. Except the larva of crinozoa which becomes sedentary, the larva of Asterozoa, Ophurozoa, Echinozoa and Holothurozoa have some fundamental resemblances. They are all constructed on the same general plan with bilateral symmetry, somewhat flattened body, longitudinally looped ciliated bands, gut and enterocoelic coelom. They exhibit so many characters in common that one may naturally conclude the origin of their respective groups from a ancestor which was coelomate bilateral and free-swimming. The zoologists have suggested two hypothetical ancestor dipleurula and pentactula larva from which all modern echinoderms might have evolved (1).

Larval similarities do not indicate taxonomic affinities within the phylum. Among Elutherozoa, two well-marked larval types occur. Pluteus group with eel-shaped

forms, bilateral symmetry and long arms, is common to ophiuroids and echinoids. Auricularia group with barrel-shaped forms and a winding ciliated band which may be produced into lobes, is common to asteroids and holothurians (1, 2). On the basis of larval similarities, the ophiuroids should be placed near to the echinoids, and asteroids near to the holothurians. But this is in total disagreement with the results of palaeontology and morphology according to which the asteroids and ophiuroids are closely related to each other while echinoids seem to have followed an entirely independent evolution. The resemblance between the ophiopluteus and echinopluteus must be due to convergent larval evolution. Occurrence of convergent types of development is seen among unrelated groups such as Asterozoa, Holotherozoa and Crinozoa. Similarly, the difference between asteroid and ophiuroid larvae must be due to divergent larval evolution. Occurrence of divergent types of development is seen within related groups (ophiuroida). This very well illustrates the unreliability of larval structures as a guide in determining the phylogenetic affinities in the echinoderms. The auricularia larva of Echinodermata presents very close and striking resemblance to the tornaria larva of some Enteropneusta. Moreover, cleavage is indeterminate and the mesoderm and coelom (enterocoel) have similar origin in the echinoderms and lower chordates have long been regarded as phylogenetically related groups. Beyond the coelenterate diploblastic condition, there were two main courses of evolution, the Mollusca-Annelida-Arthropoda line, and the Echinodermata-Chordata line leading to the highest vertebrates. However, this well established theory is now in dispute. This further concludes that to deduce taxonomy affinities based on larval resemblances is unreliable and hence inadmissible (Fig. 2).

16. Economic importance:

Sea stars have some economic importance. They are used as scavengers feeding as they do on the bodies or fragments of dead animals in the sea. On the other hand, sea stars destroy oysters and other marine animals that serve as human food.

The amount of damage done may be considerable. A single sea star placed in a dish with good-sized oysters devoured over 50 of them in 6 days. Since the sea star is such a great menace, the oyster fisherman attempts to get rid of them. They bridge up the sea star by sweeping across an oyster bed with a long mop made up of frayed rope ends. When a fiber of a mop is drawn across a sea star, the pedicellariae close over it and hang on. The mop is pulled out of the water, and the sea stars are taken off. Formerly, the fisherman simply cut the sea star in two and threw them back into the water. Some of them were eaten by other animals, some became infected and died, but others regenerated and multiplied the number of animals. When this was discovered, the sea stars are no longer thrown back, but they are carried ashore to be deposited there to die or used as a fertilizer. Another method of control involves the application of lime to the oyster beds.

Bipinnaria larva swims for few weeks in the sea water. It finally transforms into next larval stage called Brachiolaria larva.

17. Summary and conclusion

The familiar larval stages of the echinoderms, such as bipinnaria, auricularia, echinopluteus, and ophiopluteus, are characterized by many features that do not define the larval body plans for their respective classes. The structures that make these larvae so visually striking and identifiable are specializations for life in the plankton, providing these larval forms with adaptations to effectively capture particulate food. Once the transition to lecithotrophy occurs, then it is possible, and very common, for substantial changes to occur in the external morphology of these larvae. Both functional analyses of larval design for swimming and feeding, and developmental studies of the changes that underlie shifts in morphology, illustrate that these changes occur in features associated with the capture of particulate food by larvae. Many other features of larval organization remain unaltered in the evolution of nonfeeding larvae and it is these that comprise the larval body plan. It is tempting to interpret these fundamental features of larval morphology and metamorphosis (e.g., morphogenesis, organization, and postmetamorphic fates of coeloms) as conserved because of developmental constraints (i.e., features so intimately associated with the construction of the adult body plan that evolutionary change is not feasible). Yet the recent discovery of highly derived, direct development in asteroids and echinoids demonstrates without question how radically even the most basic features of development can be altered and still give rise to the same adult morphology. The only conclusion that can be supported from these observations is that it is life-history ecology (i.e., the functional demands on larvae) that imposes limits on developmental evolution and determines the associations of larval types and life-cycle character states that gives rise to the developmental patterns that we observe in marine organisms.

Echinodermata taxonomic category consists of sea stars (Asterozoa), sea urchins (Echinozoa), sand dollars (Clypeasteroidea), brittle stars (Ophiurozoa) and sea cucumbers (Holothurozoa). There are many characteristics that are shared between those five species: pentaradial symmetry (five symmetrical regions when divided across a central axis), marine habitat (all echinoderms will live underwater because they need water to survive due to their water vascular system), lack of major organs, tube feet and finally all echinoderms exhibit some form of an endoskeleton.

Echinoderms, depending on the species, can reproduce either sexually or asexually. While most reproduce sexually, some can even reproduce both ways, having the ability to grow identical organisms from its severed limbs in sexual reproduction, sperm and egg cells are typically released into open waters where fertilization occurs. Once fertilized, small eggs develop into free-swimming larva and actively will feed on its own yolk. Finally, as was mentioned before thanks to their easy and relative development and because of their gene functions ease of manipulation, echinoderms, specifically sea urchins and sea stars, is used for applying hypotheses about early developmental processes, another important characteristic of Echinoderms is their ability to regenerate, this ability lead to an increase in regenerative studies for the human body; these two reasons are why those species are significant in terms of applications in biology.

References

1. Davidson E.H., Rast J.P., Oliveri P., Ransick A., Calestani C., Yuh C.H., Minokawa T., Amore G., Hinman V., Arenas-Mena C., et al., A genomic regulatory network for development. *Science*. 2002; 295: 1669-1678
2. Ganguly, Sinha & Adhikary, *Biology Of Animals*, Volume 2, New Central Book Agency, 1988
3. Duboc V., Rottinger E., Lapraz F., Besnardeau L., Lepage T. Left-right asymmetry in the sea urchin embryo is regulated by nodal signaling on the right side. *Dev. Cell*. 2005; 9: 147-158
4. Wray, Gregory A. "Echinodermata: Spiny-skinned animals: sea urchins, starfish, and their allies?". *Tree of Life web project. Echinodermata: Fossil Record*". Introduction to the Echinodermata. Museum of Paleontology: University of California at Berkeley, 1999.
5. Hart, M. W. "Life history evolution and comparative developmental biology of echinoderms". *Evolutionary Development*. 2002, 4 (1): 62-71.
6. Wim van Egmond. "Gallery of Echinoderm Larvae". *Microscopy UK*. 2000
7. Jaeckle, William B. "Multiple Modes of Asexual Reproduction by Tropical and Subtropical Sea Star Larvae: An Unusual Adaptation for Genet Dispersal and Survival". *Biological Bulletin*. 2000, 186 (1): 62-71.

Figures and Figure Legends

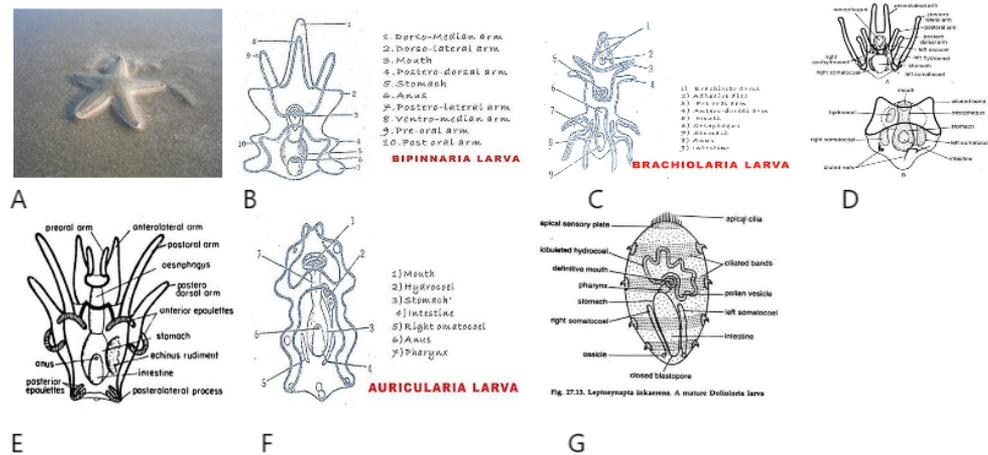


Fig.1: Different Echinodermata Larvae: A. *A. rubens*, B. Bipinnaria larva, C. Brachiolaria larva, D. Ophiopluteus larva, E. Echinopluteus larva, F. Auricularia larva, G. Doliolaria larva

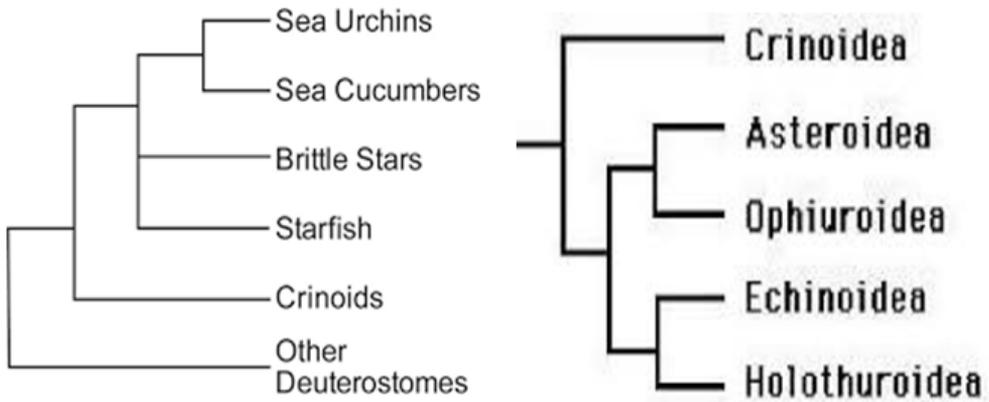


Fig. 2: Phylogenetic tree of Echinodermata

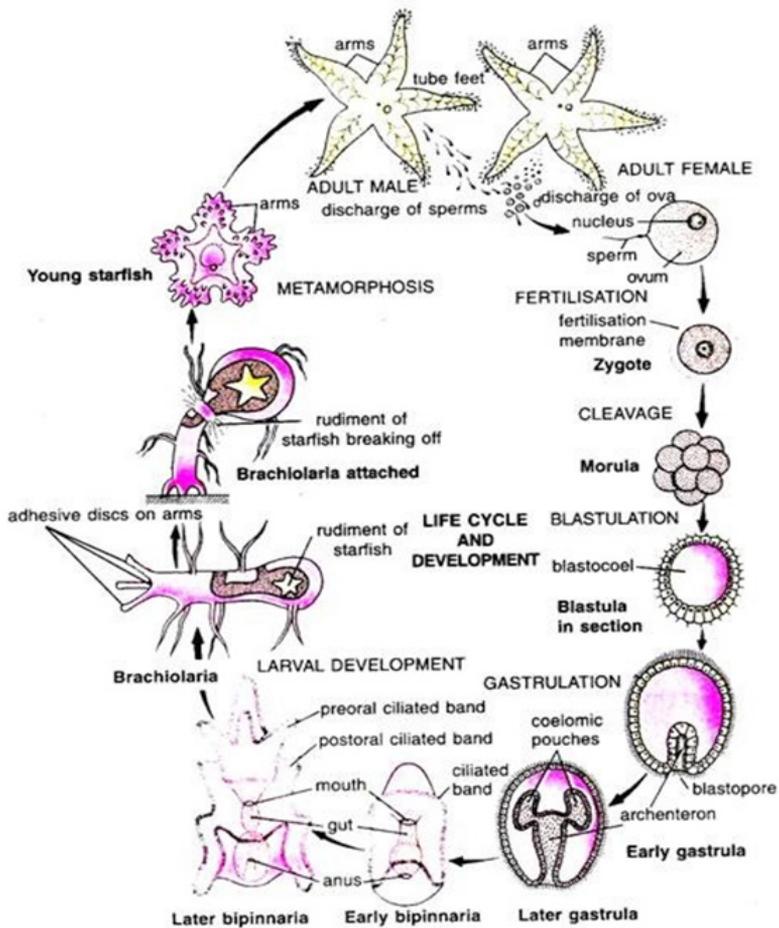


Fig. 85.14. *Asterias*. Development and life history.

Fig. 3: Development and Life cycle of *Asterias* sp.