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RESEARCH ARTICLE

Consecutive Days Maximum Rainfall Analysis by Gumbel's Extreme Value Distributions for Southern Telangana

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ABSTRACT

Annual one day maximum rainfall and two to five consecutive days maximum rainfall corresponds to return period varying from 2 to a100 years are used by design engineers and hydrologists for economic planning, design of small and medium hydrologic structures and determination of drainage parameters for agricultural lands under semi arid climate. A maximum of mean annual 1 day and 2 to 5 day consecutive rainfall was expected to 87.27mm, 108.2 mm, 119.73 mm, 128.61mm and 137.30 mm respectively. A maximum of 80.1 mm in 1 day, 93.1 mm in 2 days, 111.18mm in 3 days, 119.97 mm in 4 days, and 128.13 mm in 5 days is expected to occur at Hyderabad every 2 years. For recurrence interval of 100 years maximum rainfall expected in 1 day ,2, 3, 4 and 5 days is of 224.92 mm, 395.9 mm, 281.83 mm, 292.42 mm, and 311.12 mm respectively. The magnitude of 1 days as well as 2 to 5 consecutive days annual maximum rainfall corresponding to 2 to100 years return periods were estimated by gumble's methods for extreme event frequency analysis.

Key words: hydrologists, gumble's methods, agricultural lands, semi arid climate.

INTRODUCTION

Rainfall is one of the most important natural input resources to crop production in semi arid region. About 116.26 mha area of the country falls under rainfed farming out of a89.54 mha grossed cropped area during 1996-97. In India, the grossed irrigated area has been rapidly increasing from 28 mha in 1960-1961 to 72.8 mha in 1997-98(DES, 2001). Despite this progress, marginal and small farmers constituting 80% of agricultural income group, still depend on rainfed farming. The early or delay in onset monsoon, early or late withdrawal of monsoon, breaks in monsoon period, unusual heavy rainfall during the critical Phenol –phase of crops may disturb the normal crop growth and development . To exploit the available rainfall effectively, crop planning and management practices must be followed based on the rainfall amount and distribution at a place.

Most of the hydrological events occurring as natural phenomena are observed only once. One of the important problem in hydrology deals with the interpreting past records of hydrological event in terms of future probabilities of occurrence. The procedure adopted for estimating of the frequency of occurrence of the rainfall event in known as frequency analysis. Though the rainfall is erratic and varies with time and space, it is commonly possible to predict return period using various probability distributions (Upadhaya and Singh, 1998). Frequency analysis of rainfall data has been attempted for different places in India (Jeevrathnam and Jaykumar, 1979; Sharda and Bhushan, 1985; Prakash and Rao,1986; Aggaerwal et al., 1988; Bhatt et al., 1996; Mohanty et al., 1999; Rizvi et al., 2001; Singh, 2001; Bhakar el at., 2006; Xeflide and Ophori , 2007; Bhakar et al., 2008; Barkotulla et al., 2009).

Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances. Rainfall at 80 % probability can safely take as assured rainfall, while 50 % chance can be considered as the maximum limit for taking any risk Gupta et al). Weekly, monthly and seasonal probability analysis of rainfall data for crop planning has been attemptedby Sharma and Thkur, (1995).Prediction of rains and crop planning can be done analytically may proves a significant tool in the hands of farmers for better economic returns. Sharma et al. (1979) and prakash and Rao (1986) have suggested use of weekly rainfall data to predict the occurrence of rainy events and its amount for crop planning.

MATERIALS AND METHODS

Hyderabad of Ranga Reddy Districts is situated in between 17^0, 40', 40.4''North latitude; and 78^0, 39', 55.7'' East longitude. The climate is Dry which receives an annual rainfall is about 750 mm and about 70 % of which occurs during monsoon (June to September i.e.500 mm).

The daily rainfall data recorded and for period of 44 years (1976-2010) were used for this analysis. Annual 2 to 5 days consecutive were computed using the method described by Bhakar et al. (2006), by summing up rainfall of corresponding previous days. Maximum amount of annual 1 day to 2 to5 days consecutive rainfall for each year was used for analysis. Statistical parameters of 1 day as well as consecutive days maximum rainfall have been computed and presented in Table-1. One day to five days maximum rainfall data were fitted with Gumbels distributions.

Theoretical consideration of probability distribution:

The theories of different probability distribution are as given under. A Microsoft excel was used to fit the probability distributions.

Weibull's distribution;

The 1 day and 2 to 5 days consecutive rainfall data were analyzed for computation of probable rainfall amount at 10, 20, 30, 50.80 and 90 %. Probability level by using Weibull's equation:

$$P = \frac{m}{N+1} \text{.....(1)}$$

Where, p is the probability of occurrence, m is the rank of the observed rainfall value after arranging them in descending order of magnitude and N is the total number of years of record.

Gumbels distributions

Chows (19880 has shown that many frequency analysis can be reduced to the form of

$$X_T = X_{mean} + K_{\delta-1} \text{..... (2)}$$

Where δ_{n-1}- standard deviation
K- frequency factor expressed as

$$K = \frac{(Y_T + Y_n)}{S_n} \text{..... (3)}$$

And Y_T is the reduced variate a function of T and is given by

$$Y_T = ln.\ln\left(\frac{T}{T-1}\right) \text{..... (4)}$$

Or

$$Y_T = (0.834 + 2.330log.\log\left(\frac{T}{(T-1)}\right) \text{.....(5)}$$

Y_n is the reduced mean as a function of sample size
S_n is the reduced standard deviation as a function of sample size.

RESULTS AND DISCUSSION

The descriptive statics for rainfall data were presented in table -1which gives the 1 day and consecutive day's maximum rainfall for different return periods as determined by extreme value distribution by gumbel's method. A maximum of 204 mm in 1 day during the September 1971, 265.5 mm in 2 days, 275.6mm in 3 days and 4 days, and 285 mm in 5 days were observed during September 1971.

Table-1. Summary statistics of annual 1day as well as consecutive days maximum rainfall

Statistical parameter	1day	2day	3day	4day	5day
Minimum (mm)	33	48.40	59.10	69.20	70.30
Maximum (mm)	204	265.5	275.6	275.6	285
Mean (mm)	86.15	105.90	118.40	127.28	135.88
Standard Deviation (mm)	39.36	47.17	46.35	46.84	49.70
Coefficient of Skewness	1.49	1.60	1.49	1.24	0.99
Kurtosis	2.51	2.86	2.54	1.53	0.67

The magnitude of 1 days as well as 2 to 5 consecutive days annual maximum rainfall corresponding to 2 to100 years return periods were estimated by gumble's methods and graph were plotted rainfall verses return periods on semi logarithmic paper were presented in Fig.1

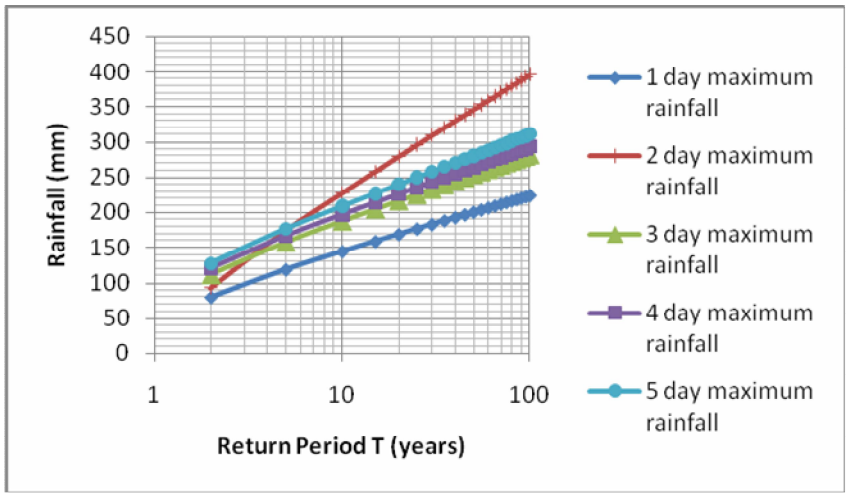

Fig. 1 probablity analysis for consecitve days of maximum rainfall

Gumbel's distribution has the property which gives T=2.33 for average of annual series of rainfall when N is very large. Thus the value of rainfall with T=2.33 year is called as the mean annual maximum rainfall. Figure shows a good fit of observed data with the theoretical variation lines indicating the applicability of Gumbels distribution to the given data. And also the mean annual maximum 1 day and 2 to 5 day consecutive rainfall was expected to 87.27mm, 108.2 mm, 119.73 mm, 128.61mm and 137.30 mm respectively

Table-2 Day as well as consecutive maximum rainfall for various Return periods

S.No	Return Period	Maximum Rainfall (mm)				
		1 day	2 day	3day	4day	5 day
1	2	80.13	93.1	111.18	119.97	128.13
2	5	118.80	174.1	156.86	166.14	177.12
3	10	144.49	227.8	187.11	196.71	209.56
4	20	169.13	279.3	216.13	226.03	240.67
5	50	201.02	345.9	253.68	263.98	280.94
6	100	224.92	395.9	281.83	292.42	311.12

Table.1 and Table 2 gives the 1 day and consecutive day's maximum rainfall for different return periods as determined by extreme value distribution by gumbel's method. A maximum of 80.1 mm in 1 day, 93.1 mm in 2 days, 111.18mm in 3 days, 119.97 mm in 4 days, and 128.13 mm in 5 days is expected to occur at Southern Telangana Region (Hyderabad) every 2 years. For recurrence interval of 100 years maximum rainfall expected in 1 day ,2, 3, 4 and 5 days is of 224.92 mm, 395.9 mm, 281.83 mm, 292.42 mm, and 311.12 mm respectively. The magnitude of 1 days

as well as 2 to 5 consecutive days annual maximum rainfall corresponding to 2 to100 years return periods were estimated by gumble's methods and is generally recommended that 2 to 100 years is sufficient return period for soil and water conservation measures, construction of farm ponds and drainage networks, irrigation planning etc.

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RESEARCH ARTICLE

Floral Diversity of Pudukkottai Narthamalai Hillock, TamilNadu, India: A Comparative study

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ABSTRACT

The present study has been carried out in Narthamalai hillock in Kulathur taluk of Pudukkottai District, TamilNadu, India, to document the current floristic composition and their status of availability in the area. A total of 385 species belonging to 273 genera and 91 families were recorded from the study area. Out of the documented species 183 (47.53%) herbs, 63 (16.36%) shrubs, 81 (21.04%) were trees and the rest 58 (15.07%) were climbers. Of all the recorded plant species, 1 species (Albizia amara) was abundant, 49 common, 182 occasional and 153 uncommon to this area. Euphorbiaceae was the dominant family, with 11 genera and 26 species, followed by Fabaceae with 16 genera and 23 species. A list of plant species along with their local names, family, habit and abundance has been given which can be utilized in the future for technological advancement, economic prosperity and providing employment opportunity to the local people. Threat to Narthamalai ecosystem is discussed and a management plan for conservation of plants in the hillock area is also suggested.

Key words: Conservation, Floristic survey, Narthamalai, Plant diversity

INTRODUCTION

Tropical forests constitute the most diverse plant communities on earth. These forests are disappearing at alarming rates owing to deforestation for extraction of timber and other forests products. Especially in South India shifting cultivation operation are most obvious causes of forests disturbances. Hence, the government of India announced these forests as reserve forests in order to conserve the forests. The problem with the chronic form of forest disturbance is that plants or ecosystem often do not get time to recover adequately because the human onslaught never stops. An obvious approach to conserve plant biodiversity is to map distributional patterns and look for concentrations of diversity and endemism. Further, management of forest requires understanding of its composition in relation to other forests, the effects of past impacts on the present status and the present relationship of the forest with surrounding land uses.

Though the present study site does not fall in hot-spot it has its own importance. Narthamalai, a hillock located in the reserve forest area of Kulathur taluk, Pudukkottai district, Tamilnadu. It is one of the largest reserve forests in Pudukkottai district and has oldest rock cut cave temples and the longest rock-cut edicts, similar to Asokan edicts which are extremely rare in the south of India. Rapid increase in land development, extensive agricultural and quarrying operations in and around Narthamalai poses significant challenges to the survivability and sustainability of Narthamalai native ecosystem. Since pre- Raja's and Nagarathaar settlement, major alterations to the Kulathur taluk have been made, due largely to urban and agricultural developments.

These activities have caused extensive degradation to native plant communities leaving remnant native lands. Therefore, the floristic diversity of these native lands is changing and a study to assess the current floristic composition is needed. Moreover, Documentation, conservation and finding enhancement strategies of biodiversity is considered to be one of the important challenges in present day conservation biology research and policy making process. Their importance is continuously being shown as they are found to be keystone for the sustainability of biosphere [1]. Meager studies are available regarding the floristic composition of hillocks present in Pudukkottai district [2, 3]. Narthamalai flora was surveyed and enumerated during the year 1970 [2]. Keeping in view the importance of the hillock, the present study is therefore, attempted to create a current plant species list and to asses the changes over a period of 30 years.

MATERIALS AND METHODS

Study area

Pudukkottai District was carved out of Tiruchirappalli and Thanjavur districts in January 1974. Pudukkottai district covers an area of 4663 Sq. Km. which has a coast line of 39 Kms. The district is located between 78.25' and 79.15' of the East of Longitude and between 9.50' and 10.40' of the North of Latitude. It is bounded by Tiruchirappalli district in the North and West, Sivaganga district in the South, Bay of Bengal in the East and Thanjavur district in the North East. It is inter spread with numerous small rocky hills. The climate of the district is hot and dry during most parts of the year.

Narthamalai is located in the Kulathur Taluk of Pudukkottai District of Tamil Nadu (TN), covering an area of about 700.44 hectares (18.47 sq. km) and inhabited by 81798 people. It is one of the reserve forests having maximum area among all the reserve forests of Pudukkottai district. The entire Narthamalai region comprises 9 hillocks namely Melamalai, Kottaimalai, Kadambarmalai, Paraiyanmalai, Uvachchanmalai, Aluruttimalai, Bombadimalai, Manmalai and Ponmalai.

Geomorphology, soils, and climate

The state consists mainly of an undulating plain, nowhere of great fertility and in many parts barren; It is interspersed with rocky hills, especially in the southwest. Granite and laterite are quarried, red ochre is worked, and silk and cotton fabrics, bell-metal vessels and perfumes are among the principal manufactures. There is also some export trade in groundnuts and tanning bark. Pudukkottai district is predominantly an agricultural oriented district. Generally a dry and hot climate prevails in this district and this district's agricultural production depends mainly on the rainfall. The normal annual rainfall of Pudukkottai district is 922.8 mm. Out of which 52.2 mm is received in winter, 124.6 mm is received in hot weather period, 351.9 mm is received during South West Monsoon and 394.1 mm is received in North East Monsoon. The climate is continental with the temperature varies from 19° C to 38° C. The altitude is about 87.78 meters (288 feet).

Coordinates of the Narthamalai

Latitude : 10.509828 N

Longitude : 78.765467 E

Field Survey and Documentation of the plants

An extensive and intensive floristic survey of Narthamalai was carried out at 30 days intervals for 1 year from August 2010 to August 2011. The entire hillock area was surveyed at every visit by walking over the slopes, tops and base of the hills. All the plants growing over the entire study area were recorded in all the seasons of the study period. During documentation of plants a closer examination of each and every area feet by feet was made in order to avoid skipping of any plant species.

Identification and creation of Plant species list

The Plant specimens were identified using various regional floras *viz*., Flora of British India [4], Flora of the presidency of Madras [5], The flora of Tamil Nadu Carnatic [6] Flora of Tamil Nadu [7], Flora of Coimbatore [8], and Indian medicinal plants [9]. Unidentified specimens were taken to the Rapinant Herbarium, Trichirappalli for proper identification and matching of the specimens.

RESULTS AND DISCUSSION

Taxonomically, a total of 385 plant species belonging to 273 genera and 91 families were recorded currently at Narthamalai reserve forests in Pudukkottai district (Table 1). Among these, 183 (47.53%) herbs, 63 (16.36%) shrubs, 81 (21.04%) were trees and the rest 58 (15.07%) were climbers including lianas. Of the 91 families, 88 belonged to angiosperms, 1 (0.26%) belonged to Bryophyte family Ricciaceae and 2 (0.52%) belonged to Pteridophytes families such as Adiantaceae and Marseliaceae. Among the 88 angiosperms families 78 were dicots and 10 were monocots. The total number of species recored in dicots was 337 (87.53%) whereas 45 (11.69 %) monocots species were recorded.

The first study about Narthamalai flora was attempted by Mathew and he enumerated 314 plant species belonging to 234 genera and 73 families during the year 1970 [2]. Presently, we recorded 71 species, 39 genera and 18 families more than that of previous study. The increase in the number of species may be due to the plantation of trees by the

forest department. The introduction of exotic or invasive species is also a valid another reason for the increase in the number of species. Though we recorded more number of species than the Mathew [2], we observed a drastic reduction in the native plant species due to human disturbances, over grazing and invasive species. About 172 species were absent at present. The taxa present in the past includes *Acalypha fruticosa, A. lanceolata, Adenia wightiana, Adenostemma lavenia, Aerva monsoniae, Allmania longepedunculata, Amischophacelus axillaris, Amischophacelus cucullata, Apocopis courtallumensis, Aristida hystirx, Barleria cristata, B. nitida, B. noctiflora, Barringtonia acutangula, Blepharis molluginifolia, Blumea amplectens, Cadaba trifoilolata, Canavalia ensiformis, Canscora heteroclite, Canscora wallichii, Canthium dicoccum, Caralluma attenuate, Caralluma umbellate, Carmona microphylla, Cassia absus, Cassia pumila, Catharanthus pusilles, Celosia argentea, C. polygonoides, Centranthera tranguebarica, Ceropegia juncea, C. tuberose, Chrysopogon fulvus, C. hackelii, Chukrasia tabularis, Cissus vitiginea, Cleome aspera, Coccinia cordifolia, Coleus canisus, Combretum ovalifolium, Commelina paleata, Cordia monoica, Crotalaria biflora, Crotalaria pusilla, Ctenolepis garcini, Cyanotis arachnoidea, C. cristata, Cymbopogon flexuosus, Cyperus castaneus, C. compressus, C. distans, C. exaltatus, C. pangorei, C. procerus, C. squarrosus, Desmodium triflorum, Digitaria adscendens, Digitaria tomentosa, Dioscorea oppositifolia, Diospyros Montana, Dolichos trilobus, Dopatrium lobelioides, Dregea volubilis, Drypetes sepiaria, Echinochloa colonum, Ehretia laevis, Elaeodendron paniculatum, Elytraria acaulis, Emilia scabra, Eragrostiella bifaria, Eragrostis nutans, Eragrostis riparia, Erigeron asteroids, Eriocaulon quinquangulare, Eriochloa procera, Eulophia epidendraea, E. prostrate, Ficus amplissima, F. mollis, Fimbristylis uliginosa, Flacourtia indica, Gardenia resinifera, Grewia emarginata, Grewia hirsute, Guazuma tomentosa, Habenaria platyphylla, H. viridiflora, Hackelochloa granularis, Heliotropium scabrum, H. zeylanicum, Heteropogon contortus, Hibiscus lobatus, Hoppea dichotoma, Hugonia mystax, Hydrolea zeylanica, Ichnocarpus frutesceus, Indigofera hirsute, Ipomoea asarifolia, Iseilema prostratum, Jaminum ritchiei, J. rigidum, Jatropha glandiflora, Kirganelia reticulate, Leptochloa polystachya, Limnophila aromatic, Limnophila Indica, Lindernia oppositifolia, L. parviflora, L. rotundifolia, L. tenuifolia, Lipocarpha triceps, Lopholepis ornithocephala, Ludwigia perennis, Maba buxifolia, Manikara hexandra, Maytenus emariginata, Melochia corchorifolia, Memecylon grande, Memecylon umbellatum, Mimosa rubicaulis, Molineria trichocarpa, Monochronia vaginalis, Murdannia nudiflora, M. spirata, Naregamia alata, Oldenlandia gracilis, Ormocarpum Sennoides, Osbeckia Zeylanca, Panicum repens, Paspalum scorbiculatum, Pavonia patens, Phyllanthus gardnerianus, Polygala chinensis, Polygala erioptera, Pristmera indica, Prosopsis cineraria, Pterospermum suberifolium, Resissatica indica, Rhusmy sorensis, Rhychosia suaveolens, Rhynchosia minima, Rivea hypocrateriformis, Rotala verticillaris, Ruellia colorata, Sacamone emetic, Scilla hyacinthine, Sapium insigne, Scripus articulates, S. sguarrous, Scutia circumcissa, Sebistiania chamaela, Sesamum lacinatum, Setaria Pallide fusca, Solena heterophylla, Stemodia viscose, Striga gesnerioides, Synnema uliginosum, Tarenna asiatica, Taxillus cuneatus, Tephrosia hirta, T. maxima, T. spinosa, Trachys muricata, Triumfeta rotundifolia, Utricularia caerulea, U. scandens, U. striatula, U. uliginosa, Vanda spathulata* and *Xyris pauciflora.* There are many examples for the reduction in the native species in regional or even global distribution due to human disturbances, over grazing and invasive species [10]. (Sudhakar Reddy and Pattanaik, 2009).

Out of the documented plant species, 1 species (Albizia amara) was abundant, 49 common, 182 occasional and 153 uncommon to this area. Euphorbiaceae was the dominant family, with 11 genera and 26 species, followed by Fabaceae (16 genera and 23 species), Acanthaceae (10 genera and 18 species), Amaranthaceae (9 genera and 16 species), Rubiaceae (11 genera and 15 species), Ceasalpinaceae (8 genera and 15 species), Mimosaceae (8 genera and 15 species), and Poaceae (12 genera) and Convolvulaceae (4 genera) with 14 species each, Asteraceae (13 species) Malvaceae, Cyperaceae and Asclepidaceae (12 species each), Lamiaceae and Rutaceae (9 species each), Solanaceae (9 species), Cucurbitaceae and Apocynaceae and (8 species each), Verbenaceae and Capparaceae (6 species), Arecaceae, Menispermaceae, Molluginaceae, Liliaceae, Moraceae Sapindaceae and Stericulaceae (4 species each), Agavaceae, Boraginaceae, Commelinaceae, Linderniaceae, Oleaceae, Polygonaceae and Scrophulariaceae (3 species each), Anacardiaceae, Annonaceae, Aizoaceae, Aristolochiaceae, Burseraceae, Cactaceae, Caryophyllaceae, Eriocaulaceae, Gentiaceae, Lentibulariaceae, Loganiaceae, Loranthaceae, Lythraceae, Meliaceae, Myrtaceae, Onagraceae, Orobanchaceae, Pedaliaceae, Rhamnaceae, Tiliaceae and Vitaceae (2 species each), Nyctaginaceae, Nymphaeaceae, Portulacaceae and Alangiaceae, Araceae, Aponogetonaceae, Bignoniaceae, Bombacaceae, Cassythaceae, Ceratophyllaceae, Cordiaceae, Ehretiaceae, Flinderaceae, Hernandiaceae, Hyacinthaceae, Hypoxidaceae, Marsilaceae, Melastomataceae, Menyanthaceae, Moringaceae, Orchidaceae, Oxalidaceae, Papaveraceae, Passifloraceae,

Plumbaginaceae, Polypodiaceae, Rananculaceae, Rosaceae, Salninaceae, Salvadoraceae, Sapotaceae, Simaroubaceae, Ulmaceae, Violaceae, Zingiberaceae and Zygophyllaceae (1 species each).In contrast, Mathew recorded Poaceae as the dominant family with 23 genera and 30 species followed by Euphorbiaceae (11 genera and 19 species), Fabaceae (12 genera and 17species), Scrophulariaceae (8 genera and 15 species), Cyperaceae (6 genera and 15 species), Acanthaceae (9 genera and 13 species), Asteraceae (11 genera and 12 species), Asclepidaceae (9 genera and 11 species), Amaranthaceae (6 genera and 10 species), Rubiaceae (8 genera and 9 species), Commelinaceae (4 genera and 8 species), Lamiaceae (7genera and 7 species), Caesalpinaceae (3 genera and 7 species), Mimosaceae (6 genera and 7 species), Liliaceae (5 genera and 5 species), Malvaceae (3 genera and 5 species), Capparaceae, Uriticaceae (2 genera and 5 species), Apocynaceae, Boraginaceae, Convolvulaceae, Gentinaceae (4 genera and 5 species), Lentibulariaceae (1 genus and 4 species), Rutaceae, Stericulaceae, Verbenaceae (4 genera and 4 species), Tiliaceae (2 genera and 4 species), Orchidaceae (3 genera and 4 species), Cucurbitaceae, Meliaceae, Pedaliaceae (3 genera and 3 species), Melastomataceae (2 genera and 3 species), Rhamnaceae (2 genera and 3 species), Vitaceae (1 genus and 3 species), Aizoaceae, Amaryllidaceae, Arecaceae, Celastraceae, Ebenaceae, Hypocrateaceae, Menispermaceae, Passifloraceae, Sapindaceae (2 genera and 2 species), Droseraceae, Eriocaulaceae, Oleaceae, Polygalaceae (1 genus and 2 species) and Alangiaceae, Anacardiaceae, Aponogetonaceae, Aristolochiaceae, Burseraceae, Cactaceae, Carophyllaceae, Combretaceae, Dioscoreaceae, Flacourtiaceae, Hernandiaceae, Hydrophyllaceae, Lauraceae, Lecythidaceae, Linaceae, Loganiaceae, Loranthaceae, Myrtaceae, Nyctaginaceae, Pontederiaceae, Portulacaceae, Salvadoraceae, Sapotaceae, Violaceae, Xyridaceae, Zygophyllaceae (1 genus and 1 species).

The change in the dominant species, drastic decrease in the number of native species and increase in the number of invasive species are the indication of structural change in the natural ecosystem. The problem is that most native communities already have been changed beyond recognition by humans, and many native species are now rare in Narthamalai. It is widely believed that the most effective way to limit plant invasions is to prevent the introduction of exotic species, which may be difficult because of the ongoing expansion in global travel and trade, changes in environments at all scales (local to global), and increasing development of land for human use. Though some invasive, human-introduced plants are definitely problematic, others could serve to restore ecological balance by providing essential food resources to native fauna that populate areas affected by humans. Invasive species could fill niches in degraded ecosystems and help restore native biodiversity in an inexpensive and self-organized way that requires little or no human intervention. If we are eliminating an invasive species, it could result in harm to the newly formed balance of an ecosystem, large-scale attempts to remove species also could be a waste of time and tax rupees. Nature is in a constant state of flux, always shifting and readjusting as new relationships form between species, and not all of these relationships are bad just because they are novel or created by humans.

CONCLUSION

The research study has identified biodiversity assets, components of ecosystem function, threats and other factors that influence conservation outcome and highlighted a number of management issues that remain to be solved. Foremost among these is the need to develop methods to manage or restore and maintain or improve biodiversity in the hillock in the plain area. For this an approach is needed for effective environmental management framework combining research and action. Further research is also required to develop methods to replace natural disturbance regimes, reduce weed cover and revegetation prescriptions to restore buffers and hillock zonation. In addition to that, additional survey work is required to describe more comprehensively the floristic composition and vegetation zonation at hillock sites and remnant hillock vegetation, and their environmental correlates, to expand and improve the hillock vegetation classification to better understand the distribution and environmental correlates of hillock on the Narthamalai and their relationship to Ecological Vegetation Classes and to determine the importance of the hillock as habitat for native fauna, evaluation of buffer quality and value of hillock vegetation surrounding (improved vs. unimproved).

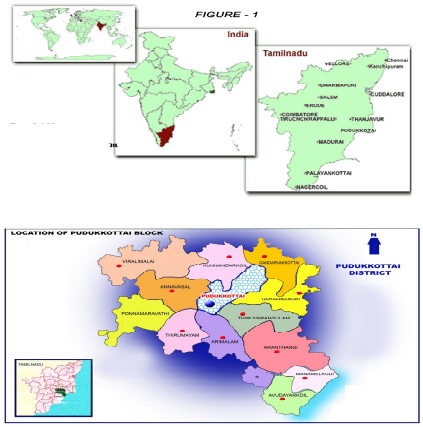

Fig 1: Study area

Fig 2: *Acalypha ciliata* L.

Fig 3 :*Gloriosa superba* L.

Fig 4 : *Adiantum pedatum* L.

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S.No.	Botanical Name	Vernacular name	Family	Habit	Abundance
1	*Abelmoschus ficulneus (L.) Wight & Arn.*	Kaatuvendai	Malvaceae	Un-shrub	Occasional
2	*Abrus precatorius L.*	Kundumani	Fabaceae	Climber	Rare
3	*Abutilon indicum (L.) Sweet.*	Thutthichedi	Malvaceae	Un-shrub	Occassional
4	*Acacia ferrugina (Guill. & Perr.) Benth.*	Simavelvel	Mimosaceae	Deciduous tree	Occassional
5	*Acacia horrida (L.) Willd.*	Kakkamul	Mimosaceae	Un-shrub	Occassional
6	*Acacia mearnsii De Wild.*	Velamaram	Mimosaceae	Tree	Rare
7	*Acacia arabica Sensu Baker.*	Karuvelaamaram	Mimosaceae	Tree	Rare
8	*Acacia leucophloea (Roxb.) Willd.*	Vellaivelan	Mimosaceae	Tree	Rare
9	*Acacia nilotica (L.) Willd.. Ex Del.*	Velanmaram	Mimosaceae	Tree	Occassional
10	*Acacia polyacantha Willd.*	Seengai	Mimosaceae	Tree	Occassional
11	*Acalypha ciliata Forssk.*	Kuppi	Euphorbiaceae	Herb	Rare
12	*Acalypha indica L.*	Kuppaimeni	Euphorbiaceae	Herb	Occassional
13	*Acanthospermum hispidum DC.*	Mullichedi	Asteraceae	Herb	Rare
14	*Achyranthus aspera L.*	Naaiyuruvi	Amaranthaceae	Herb	Common
15	*Adiantum pedatum L.*	Mayilkondai	Adiantaceae	Fern	Rare
16	*Aegle marmelos (L.) Correa Ex. Shultz.*	Vilvam	Rutaceae	Tree	Rare
17	*Aerva javanica (Burm.F.) Juss. Ex Schult.*	Not recorded	Amaranthaceae	Herb	Rare
18	*Aerva lanata (L.) Juss. Ex. Shultz.*	Poolaipoo	Amaranthaceae	Herb	Common
19	*Aeschynomene aspera L.*	Kidaichchi	Fabaceae	Herb	Rare
20	*Agave angustifolia Haw.*	Katthalai	Agavaceae	Herb	Common
21	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.	Poompillu	Asteraceae	Herb	Occassional
22	*Ageratum conyzoides L.*	Poompillu	Asteraceae	Herb	Occassional
23	*Agropyron repens Beauv.*	Naaippul	Poaceae	Herb	Occassional
24	*Ailanthus excelsa Roxb.*	Vathikuchimaram	Simaroubaceae	Tree	Rare
25	*Alangium salvifolium (L.F.) Wang.*	Azhingil	Alangiaceae	Tree	Occassional
26	*Albizia amara (Roxb.) Boivin.*	Usil	Mimosaceae	Tree	Very Common
27	*Albizia lebbeck (L.) Benth.*	Vaagaimaram	Mimosaceae	Tree	Occassional
28	*Allmania nodiflora (L.) R.Br. Ex Wight.*	Vannikkeerai	Amaranthaceae	Herb	Occassional

29	*Aloe barbadensis Mill.*	Chotthukatthalai	Liliaceae	Herb	Rare
30	*Alternanthera philoxeroides (Mart.) Griseb.*	Not recorded	Amaranthaceae	Herb	Occassional
31	*Alternanthera pungens Kunth.*	Kaaki chedi	Amaranthaceae	Prostrate herb	Occassional
32	*Alternanthera sessilis (L.) R.Br.Ex DC.*	Ponnanganii	Amaranthaceae	Prostrate herb	Occassional
33	*Alysicarpus monilifer (L.) DC*	Ottupullu	Fabaceae	Herb	Common
34	*Amaranthus spinosus L.*	Mullukeerai	Amaranthaceae	Herb	Occassional
35	*Amaranthus viridis L.*	Kuppaikeerai	Amaranthaceae	Herb	Occassional
36	*Ammannia baccifera L.*	Neermel nerupu	Lythraceae	Herb	Occassional
37	*Andrographis echioides (L.f.) Nees.*	Gopuramthangi	Acanthaceae	Herb	Occassional
38	*Andrographis paniculata (Burm.f.)Wallich Ex Nees.*	Nilavaemboo	Acanthaceae	Herb	Rare
39	*Anisochilus carnosus Wall.*	Karpooravalli	Lamiaceae	Erect herb	Occassional
40	*Anisomeles indica (L.) O.Kuntze.*	Vattapeymarutti	Lamiaceae	Herb	Rare
41	*Anisomeles malabarica R.Br. Ex Sims.*	Paeimirati	Lamiaceae	Un-shrub	Occassional
42	*Annona squamosa L.*	Seetha pazham	Annonaceae	Tree	Occassional
43	*Antigonon leptopus* Hook. & Arn.	Not recorded	Polygonaceae	Climber	Common
44	*Aponogeton natans (L.) Engl. & Krause.*	Kottikilangu	Aponogetonaceae	Very small	Common
45	*Argemone mexicana L.*	Biramathandu	Papaveraceae	Herb	Rare
46	*Aristida setacea Retz.*	Thudappampillu	Poaceae	Herb	Common
47	*Aristolochia bracteolata Lam.*	Aduthinnappalai	Aristolochiaceae	Trailer	Rare
48	*Aristolochia indica L.*	Perumarundukodi	Aristolochiaceae	Trailer	Rare
49	*Asparagus racemosus Willd.*	Thannirvittankizhangu	Liliaceae	Climber	Rare
50	*Asystasia gangetica (L.) T. Anderson.*	Parchorri	Acanthaceae	Herb	Occassional
51	*Atalantia monophylla DC.*	Kattu elumichai	Rutaceae	Shrub	Occassional
52	*Atalantia racemosa Wight Ex Hook.*	Kattukkolunci	Rutaceae	Shrub	Rare
53	*Azadirachta indica A. Juss.*	Vembu	Meliaceae	Tree	Occassional
54	*Azima tetracantha Lam.*	Sanguchedi	Salvadoraceae	Stra-shrub	Occassional
55	*Bacopa monnieri (L.) Pennell.*	Neerbrahmi	Scrophulariaceae	Herb	Occassional
56	*Bambusa arundinacea Willd.*	Moongil	Poaceae	Tree	Rare
57	*Barleria prionitis L.*	Kaatukanagambaram	Acanthaceae	Shrub	Rare

58	*Bauhinia racemosa Lam.*	Aathimaram	Caesalpiniaceae	Tree	Rare
59	*Benkara malabarica (Lam.) Tirveng.*	Pidavam	Rubiaceae	Tree	Rare
60	*Blepharis maderaspatensis (L.) Roth.*	Netthirappoondu	Acanthaceae	Herb	Occassional
61	*Boerhavia diffusa L.*	Saaranai Keerai	Nyctaginaceae	Creeper	Occassional
62	*Borassus flabellifer L.*	Panai	Arecaceae	Tree	Occassional
63	*Brachiaria ramosa Stapf.*	Not recorded	Poaceae	Herb	Common
64	*Bulbostylis barbata Rottb.*	Mukkorraikkorai	Cyperaceae	Herb	Common
65	*Butea monosperma (Lam.) Taub.*	Thenthangkottai	Fabaceae	Tree	Rare
66	*Cadaba fruticosa (L.) Druce.*	Kunkilatikacceti	Capparaceae	Tree	Rare
67	*Calotropis gigantea (L.) R.Br*	Arukku	Asclepidaceae	Shrub	Occassional
68	*Calotropis procera R.Br.*	Vellai erukku	Asclepidaceae	Shrub	Rare
69	*Canthium coromandelicum N. Burm.*	Kaarai	Rubiaceae	Shrub	Occassional
70	*Capparis zeylanica L.*	Adhandai	Capparaceae	Staggler	Rare
71	*Caralluma adscendens (Roxb.) Haw.*	Kallimulayan	Asclepidaceae	Herb	Occassional
72	*Cardiospermum halicacabum L.*	Mudakkathan	Sapindaceae	Climber	Rare
73	*Carissa carandas L.*	Kilakkaay	Rubiaceae	Shrub	Occassional
74	*Carissa spinarum L.*	Cirukala	Rubiaceae	Shrub	Occassional
75	*Cassia roxburghii DC.*	Kondrai maram	Caesalpiniaceae	Tree	Rare
76	*Cassia fistula L.*	Manjal kondrai	Caesalpiniaceae	Tree	Rare
77	*Cassytha filiformis L.*	Kottankodi	Cassythaceae	Climber	Rare
78	*Catharanthus roseus (L.) G.Don.*	Nithyakalyani	Apocynaceae	Herb	Rare
79	*Catunaregam spinosa (Thunb.) Tirveng.*	Madukarei	Rubiaceae	Shrub	Occassional
80	*Ceiba pentandra (L.) Gaertn.*	Ilavampanchu	Bombacaceae	Tree	Rare
81	*Celosia cristata L.*	Pannaikeerai	Amaranthaceae	Herb	Rare
82	*Ceratophyllum demersum L.*	Neerpul	Ceratophyllaceae	Herb	Occassional
83	*Cereus pterogonus Lem.*	Railkalli	Cactaceae	Shrub	Occassional
84	*Chloris barbata SW.*	Cevvarakupul	Cyperaceae	Herb	Common
85	*Chloroxylon swietenia DC.*	Vammaram	Flinderaceae	Tree	Rare
86	*Cissampelos pareira L.*	Ponmusattai	Menispermaceae	Climber	Occassional
87	*Cissus quadrangularis L.*	Pirandai	Vitaceae	Climber	Occassional

88	*Cissus setosa Roxb.*	Mulampirandai	Vitaceae	Climber	Occassional
89	*Citrullus colocynthis (L.) Schrader.*	Komatti	Cucurbitaceae	Trailer	Rare
90	*Citrullus vulgaris Schrader.*	Karukkummatti	Cucurbitaceae	Creeper	Rare
91	*Citrus aurantium L.*	Naarthai	Rutaceae	Tree	Rare
92	*Citrus medica L.*	Kodielumicchai	Rutaceae	Tree	Rare
93	*Clausena dentata (Willd) Roeme.*	Kattukkaruveppilai	Rutaceae	Shrub	Occassional
94	*Cleistanthus collinus (Roxb.) Benth. & Hook.*	Otukkuppalai	Euphorbiaceae	Tree	Rare
95	*Clematis gauriana Roxb.*	Not recorded	Rananculaceae	Climber	Occassional
96	*Cleome gynandra L.*	Naivelai	Capparaceae	Herb	Rare
97	*Cleome monophylla L.*	Ucivelai	Capparaceae	Herb	Rare
98	*Cleome viscosa L.*	Naikkadugu	Capparaceae	Herb	Common
99	*Clitoria ternatea L.*	Sanguppu	Fabaceae	Climber	Rare
100	*Coccinia grandis (L.) Voigt.*	Kovai	Cucurbitaceae	Climber	Occassional
101	*Coccinia trilobata (Cogn.) C.Jeffrey.*	Koval	Cucurbitaceae	Climber	Rare
102	*Cocculus villosus DL.*	Sirikattukkodi	Menispermaceae	Climber	Occassional
103	*Cocculus hirsutus (L.) Diels.*	Kattukkodi	Menispermaceae	Climber	Rare
104	*Cocos nucifera L.*	Thennai	Arecaceae	Tree	Occassional
105	*Coldenia procumbens L.*	Seruppadai	Boraginaceae	Herb	Common
106	*Colocasia esculenta (L.) Schott.*	Sempu	Araceae	Herb	Rare
107	*Commelina benghalensis L.*	Kanavalai	Commelinaceae	Herb	Occassional
108	*Commelina communis Eugelm. EX Kunth.*	Not recorded	Commelinaceae	Herb	Occassional
109	*Commelina diffusa Burm. f.*	Kananagakarai	Commelinaceae	Herb	Occassional
110	*Commiphora berryi (Arn.) Engl.*	Mudgiluvai	Burseraceae	Tree	Common
111	*Commiphora caudata (Wight & Aan.) Engler.*	Malaikiluvai	Burseraceae	Tree	Occassional
112	*Corchorus aestuans L.*	Siruvalichedi	Tiliaceae	Herb	Occassional
113	*Cordia obliqua Willd.*	Naruvili	Cordiaceae	Tree	Occassional
114	*Corypha umbraculifera L*	Kudaipanai	Arecaceae	Tree	Rare
115	*Crateva adansonii Dunn.*	Mavalingamaram	Capparaceae	Tree	Rare
116	*Crossandra undulaefolia Sallisb.*	Delikanakambaram	Acanthaceae	Herb	Occassional

117	*Crotalaria laburnifolia L.*	Kilukiluppai	Fabaceae	Herb	Rare
118	*Crotalaria medicaginea Lam.*	Not recorded	Fabaceae	Herb	Rare
119	*Crotalaria verrucosa L.*	Not recorded	Fabaceae	Herb	Rare
120	*Croton bonplandianum Baill.*	Reilpoondu	Euphorbiaceae	Herb	Occassional
121	*Ctenolepis cerasiformis (Stocks) Hook. f.*	Kakkarikkay	Cucurbitaceae	Creeper	Occassional
122	*Curculigo orchioides Gaertn.*	Kurumpalaikkilanku	Hypoxidaceae	Herb	Rare
123	*Cymbopogon citratus (DC.) Stapf.*	Elumichaipullu	Poaceae	Herb	Common
124	*Cymbopogon martini (Roxb.) W.Watson.*	Kavattampillu	Poaceae	Herb	Occassional
125	*Cynodon dactylon (L.) Pers.*	Arugampullu	Poaceae	Herb	Occassional
126	*Cyperus rotundus L.*	Korai kilangu	Cyperaceae	Herb	Occassional
127	*Cyperus triceps (Rottb.) Endl.*	Korai	Cyperaceae	Herb	Common
128	*Cyperus tuberosus Rottb.*	Neerkkorai	Cyperaceae	Herb	Occassional
129	*Dactyloctenium aegyptium (L.) Willd.*	Mattankayppul	Poaceae	Herb	Common
130	*Datura stramonium L.*	Karuoomathai	Solanaceae	Herb	Rare
131	*Datura metel L.*	Oomathai	Solanaceae	Herb	Occassional
132	*Delonix elata (L.) Gamble.*	Vathanarayanamaram	Ceasalpinaceae	Tree	Rare
133	*Delonix regia (Hook.) Raf.*	Mayilkondai	Ceasalpinaceae	Tree	Rare
134	*Dendrophthoe falcata (L.F) Etting.*	Pulluruvi	Loranthaceae	Shrub	Rare
135	*Derris scandens (Roxb.) Benth.*	Anaikellikodi	Fabaceae	Liana	Occassional
136	*Dichrostachys cinerea Wight & Arn.*	Karukavimaram	Mimosaceae	Tree	Occassional
137	*Digera muricata (L.) Mart.*	Chennaiyuruvi	Amaranthaceae	Herb	Occassional
138	*Dipteracanthus patulus (Jacq.) Nees.*	Kattunayakacceti	Acanthaceae	Herb	Occassional
139	*Dipteracanthus prostratus (Poir.) Nees.*	Pottakanchi	Acanthaceae	Herb	Occassional
140	*Dodonaea viscosa subsp. angustifolia (L.f.) J.G.West.*	Virali	Sapindaceae	Un-shrub	Rare
141	*Dodonaea viscosa (L.) Jacq.*	Virali	Sapindaceae	Un-shrub	Common
142	*Drosera indica L.*	Poochi thinni chedi	Droseraceae	Herb	Rare
143	*Drosera burmannii Vahl.*	Nalakanni	Droseraceae	Herb	Rare
144	*Drynaria quercifolia (L.) J.Smith.*	Not recorded	Polypodiaceae	Herb	Rare
145	*Ecbolium ligustrinum (Vahl) Vollesen.*	Pachai kanakambaram	Acanthaceae	Herb	Rare
146	*Eclipta prostrata (L.) L.*	Karusalanganni	Asteraceae	Herb	Rare

147	*Ehretia microphylla Lam.*	Kattu vetrilai	Ehretiaceae	Shrub	Occassional
148	*Emilia sonchifolia (L.) DC.*	Muyalccevi	Asteraceae	Herb	Rare
149	*Enicostemma axillare (Lam.) Raynal.*	Parataviturantam	Gentiaceae	Herb	Occassional
150	*Enicostemma littorale Blume.*	Vellarrukku	Gentiaceae	Herb	Rare
151	*Eragrostis pilosa (L.) P. Beauv.*	Sempullu	Poaceae	Herb	Common
152	*Eragrostis viscosa (Retz.) Trin.*	Gadi Pullu	Poaceae	Herb	Common
153	*Eriocaulon carsonii F.Muell.*	Not recorded	Eriocaulaceae	Aquatic Herb	Common
154	*Eriocaulon cinereum R.Br.*	Not recorded	Eriocaulaceae	Aquatic Herb	Occassional
155	*Erythrina variegata L.*	Mullumurunkaimaram	Fabaceae	Tree	Rare
156	*Eucalyptus globulus Labill.*	Eucalyptus	Myrtaceae	Tree	Occassional
157	*Euphorbia antiquorum L.*	Chathurakkalli	Euphorbiaceae	Shrub	Occassional
158	*Euphorbia corrigioloides Boiss.*	Not recorded	Euphorbiaceae	Shrub	Occassional
159	*Euphorbia heterophylla (Murray) Boiss.*	Not recorded	Euphorbiaceae	Herb	Rare
160	*Euphorbia cyathophora L.*	Palperukki	Euphorbiaceae	Herb	Rare
161	*Euphorbia hirta L.*	Ammanpachaiarisi	Euphorbiaceae	Herb	Occassional
162	*Euphorbia microphylla Heyne.*	Not recorded	Euphorbiaceae	Shrub	Occassional
163	*Euphorbia tirucalli L.*	Tirukkalli	Euphorbiaceae	Shrub	Rare
164	*Euphorbia tortilis Rottler.*	Thirukukalli	Euphorbiaceae	Shrub	Occassional
165	*Evolvulus alsinoides L.*	Vishnukranthi	Convolvulaceae	Creeper	Common
166	*Exacum pedunculatum L.*	Kanap-pundu	Convolvulaceae	Creeper	Occassional
167	*Falconeria insignis Royle.*	Not recorded	Euphorbiaceae	Shrub	Rare
168	*Feronia limonia (l.) Swingle.*	Vilampalam	Rutaceae	Tree	Occassional
169	*Ficus bengalensis L.*	Aalamaram	Moraceae	Tree	Occassional
170	*Ficus racemosa L.*	Atthi	Moraceae	Tree	Rare
171	*Ficus religiosa L.*	Arasamaram	Moraceae	Tree	Rare
172	*Fimbristylis miliacea L. & Vahl.*	Not recorded	Cyperaceae	Herb	Occassional
173	*Fimbristylis ovata (Burm.f.) J.Kern.*	Not recorded	Cyperaceae	Herb	Occassional
174	*Fuirena ciliaris (L.) Roxb.*	Not recorded	Cyperaceae	Herb	Occassional
175	*Furcaria foetida (L.) Haw.*	Parukikkarralai	Agavaceae	Herb	Occassional
176	*Geniosporum tenuiflorum (L.) Merrill.*	Marumatikkoluntu	Lamiaceae	Herb	Rare

177	*Gisekia pharnaceoides L.*	Manalikkirai	Molluginaceae	Herb	Occassional
178	*Glinus lotoides L.*	Circuceruppatai	Aizoaceae	Herb	Occassional
179	*Glinus oppositifolius (L.) A.DC.*	Turayilaippuntu	Aizoaceae	Herb	Occassional
180	*Gloriosa superba L.*	kalappaikizhangu	Liliaceae	Climber	Rare
181	*Gmelina asiatica L.*	Kumizha maram	Verbenaceae	Tree	Occassional
182	*Gomphrena globosa L.*	Vaadaamalli	Amaranthaceae	Herb	Rare
183	*Gymnema sylvestre R.Br.*	Sirukkurinja	Asclepidaceae	Climber	Occassional
184	*Gyrocarpus americanus Jacq.*	Puttiramancarimaram	Hernandiaceae	Tree	Rare
185	*Habenaria elliptica Wight.*	Not recorded	Orchidaceae	Herb	Occassional
186	*Hedyotis auricularia L.*	Valli parith	Rubiaceae	Herb	Common
187	*Heliotropium indicum L.*	Thelkodukkuchedi	Boraginaceae	Herb	Occassional
188	*Hemidesmus indicus (L.) Schult.*	Nannari	Asclepidaceae	Climber	Occassional
189	*Hibiscus cannabinus L.*	Pulichakkeerai	Malvaceae	Herb	Occassional
190	*Hibiscus rosa-sinensis L.*	Semparuthi	Malvaceae	Shrub	Rare
191	*Hibiscus vitifolius L.*	Kaarupatthi	Malvaceae	Herb	Occassional
192	*Hibiscus ovalifolius (Forsk.) Vahl.*	Nithiyamalli	Malvaceae	Herb	Occassional
193	*Holoptelea integrifolia (Roxb.) Planchon.*	Tenpuccimaram	Ulmaceae	Tree	Rare
194	*Hybanthus enneaspermus (L.F.) Muell.*	Oritaltamarai	Violaceae	Herb	Occassional
195	*Hygrophila auriculata (Schumach.) Heine.*	Nirkkumpicceti	Acanthaceae	Herb	Occassional
196	*Indigofera aspalathoides Vahl. Ex DC.*	Shivanar Vembu	Fabaceae	Herb	Occassional
197	*Indigofera linnaei Ali.*	Cenneruncil	Fabaceae	Herb	Occassional
198	*Indigofera tinctoria L.*	Kasturinilicceti	Fabaceae	Herb	Occassional
199	*Ipomoea aquatica Forssk.*	Vallaik-kodi	Convolvulaceae	Climber	Occassional
200	*Ipomoea indica (Burm.) Merr.*	Not recorded	Convolvulaceae	Climber	Occassional
201	*Ipomoea quamoclit L.*	Mayirmanikkam	Convolvulaceae	Climber	Rare
202	*Ipomoea carnea (Mart. Ex Choisy) Austin.*	Not recorded	Convolvulaceae	Climber	Occassional
203	*Ipomoea hederifolia L.*	Kodikkakkattan	Convolvulaceae	Climber	Rare
204	*Ipomoea obscura Ker.-Gawl.*	Nuraipperinikkoti	Convolvulaceae	Climber	Occassional
205	*Ipomoea pes-tigridis L.*	Punaikkirai	Convolvulaceae	Climber	Occassional
206	*Ipomoea sepiaria Roxb.*	Talikkodi	Convolvulaceae	Twiner	Occassional

207	*Ipomoea staphylina R.Br.*	Unnakankoti	Convolvulaceae	Climber	Occassional
208	*Ixora coccinea L.*	Vellaivetcippucceti	Rubiaceae	Shrub	Rare
209	*Ixora nigricans Br.*	Mashagani	Rubiaceae	Shrub	Rare
210	*Jasminum angustifolium Vahl.*	Kaattumalli	Oleaceae	Climber	Rare
211	*Jasminum grandiflorum L.*	Sadimalligai	Oleaceae	Climber	Rare
212	*Jasminum sambac (L.) Ait..*	Aanaimalli	Oleaceae	Climber	Rare
213	*Jatropha curcas L.*	Vellamanakku	Euphorbiaceae	Shrub	Rare
214	*Jatropha gossypifolia L.*	Kattamanakku	Euphorbiaceae	Shrub	Rare
215	*Justicia adhatoda L.*	Adathoda	Acanthaceae	Shrub	Rare
216	*Justicia gendarussa Burm.*	Karunochchi	Acanthaceae	Herb	Rare
217	*Justicia glauca B.Heyne ex Wall.*	Not recorded	Acanthaceae	Herb	Occassional
218	*Justicia simplex D. Don.*	Not recorded	Acanthaceae	Herb	Occassional
219	*Kingiodendron pinnatum (DC.) Harms.*	Madayansamprani	Caesalpinaceae	Tree	Rare
220	*Kleinhovia hospita L.*	Punaittekku	Stericulaceae	Tree	Occassional
221	*Kyllinga nemoralis (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel.*	Velutta nirbasi	Cyperaceae	Herb	Common
222	*Kyllinga triceps SW.*	Nirbasi	Cyperaceae	Herb	Rare
223	*Lablab purpureus (L.) Sweet.*	Avarai	Fabaceae	Climber	Rare
224	*Lannea coromandelica (Houtt) Mers.*	Othiyamaram	Anacardaceae	Tree	Occassional
225	*Lantana camera L.*	Arisimalar	Verbenaceae	Shrub	Rare
226	*Launaea sarmentosa (Willd.) Sch.Bip. ex Kuntze.*	Eluttanippuntucceti	Asteraceae	Herb	Occassional
227	*Lawsonia inermis L.*	Maruthani	Lythraceae	Shrub	Rare
228	*Leonotis nepetifolia (L.) R.Br.*	Ranaperi	Lamiaceae	Herb	Occassional
229	*Leptadenia reticulata (Retz.) Wight & Arn.*	Palaikkodi	Asclepidaceae	Climber	Occassional
230	*Leucaena leucocephala (Lam.) de Wit.*	Subabul	Mimosaceae	Tree	Occassional
231	*Leucas aspera (Willd.) Link.*	Thumbai	Lamiaceae	Herb	Common
232	*Lillium polyphyllum D. Don.*	Ksirakakoli	Liliaceae	Herb	Occassional
233	*Lindernia crustacea (L.) F.Muell.*	Katupeetsjangapuspam	Linderniaceae	Herb	Occassional
234	*Lindernia ruellioides (Colsm.) Pennell.*	Thasuih	Linderniaceae	Herb	Occassional
235	*Lindernia ciliata (Colsm.) Pennell.*	Pee-tsjanga-puspam	Linderniaceae	Herb	Common

236	*Loranthus longiflorus Desr.*	Pulluruvi	Loranthaceae	Parasitic Shrub	Rare
237	*Ludwigia palustris (L.) Elliott.*	Muyarkatilai	Onagraceae	Herb	Common
238	*Ludwigia parviflora Roxb.*	Neerkirambu	Onagraceae	Herb	Common
239	*Lycopersicon esculentum Mill.*	Thakkaali	Solanaceae	Herb	Rare
240	*Madhuca longifolia (J.Koenong) Macbr.*	Illuppai	Sapotaceae	Tree	Rare
241	*Mangifera indica L.*	Mamaram	Anacardaceae	Tree	Rare
242	*Marsiliea quadrifolia L.*	Aarakkeerai	Marsilaceae	Herb	Common
243	*Martynia annua L.*	Telkotukki	Pedaliaceae	Herb	Rare
244	*Melia azadarach L.*	Malai Vembu	Meliaceae	Tree	Rare
245	*Melochia corchorifolia L.*	Pinnakkukkirai	Stericulaceae	Herb	Occassional
246	*Melothria maderaspatana (L.) Cogn.*	Musumusukkai	Cucurbitaceae	Climber	Occassional
247	*Memecylon edule Roxb.*	Kayampucceti	Melastomataceae	Herb	Rare
248	*Merrremia emarginata (Burm. f) Hallier f.*	Pirattaikkirai	Convolvulaceae	Climber	Occassional
249	*Merremia hederacea (Burm. f.) Hallier f.*	Yelikkaadhukeerai	Convolvulaceae	Climber	Occassional
250	*Merremia tridentata (L.) Hallier f.*	Auvaiyar kundal	Convolvulaceae	Climber	Occassional
251	*Micromelum minutum Forest. F.*	Not recorded	Rutaceae	Tree	Rare
252	*Mimosa pudica L.*	Thottasiningi	Mimosaceae	Herb	Rare
253	*Mitragyna parvifolia Korth.*	Karpakkatampumaram	Rubiaceae	Tree	Occassional
254	*Mollugo cerviana (L.) Ser.*	Parppatakam	Molluginaceae	Herb	Occassional
255	*Mollugo nudicaulis Lam.*	Not recorded	Molluginaceae	Herb	Common
256	*Mollugo pentaphylla L.*	Turapoondu	Molluginaceae	Herb	Common
257	*Morinda pubescens Sm.*	Manjanathi	Rubiaceae	Tree	Occassional
258	*Moringa oleifera Lam*	Murungai	Moringaceae	Tree	Occassional
259	*Mucuna pruriens (L.) DC.*	Totadulagondi	Fabaceae	Climber	Rare
260	*Mukia maderaspatana (L.) M.Roemer.*	Musumusukkai	Cucurbitaceae	Climber	Occassional
261	*Murraya koenigii (L.) Spreng.*	Karuveppilai	Rutaceae	Tree	Rare
262	*Nelumbium speciosum Willd.*	Thammarai	Nymphaeaceae	Herb	Rare
263	*Neptunia natans W. Theob.*	Neer thottasinungi	Mimosaceae	Herb	Rare
264	*Nerium oleander L.*	Aralli	Apocynaceae	Shrub	Rare
265	*Nymphaea pubescens Willd.*	Alli	Nymphaeaceae	Herb	Occassional

266	*Nymphoides cristata (Roxb.) Kuntze.*	Neerpanippoo	*Menyanthaceae*	Herb	Rare
267	*Ocimum americanum L.*	Naaithulasi	Lamiaceae	Herb	Rare
268	*Ocimum canum L.*	Kukka-tulasi	Lamiaceae	Herb	Occassional
269	*Ocimum sanctum L.*	Thulasi	Lamiaceae	Herb	Occassional
270	*Ocimum tenuiflorum L.*	Tiruttulacicceti	Lamiaceae	Herb	Occassional
271	*Oldenlandia herbacea (L.) Roxb.*	Parpadagam	Rubiaceae	Herb	Occassional
272	*Oldenlandia umbellata L.*	Impural	Rubiaceae	Herb	Common
273	*Opuntia dilleni (ker-Gawl.) Jhaw.*	Chappathikalli	Cactaceae	Herb	Occassional
274	*Oxystelma esculentum (L. f.) Sm.*	Uttamai	Asclepidaceae	Climber	Rare
275	*Parthenium hysterophorus L.*	Parthenium	Asteraceae	Herb	Common
276	*Passiflora foetida L.*	Siruppunaikkali	Passifloraceae	Climber	Rare
277	*Pavetta indica L.*	Vellaippavattai	Rubiaceae	Shrub	Common
278	*Pavonia procumbens Casar.*	Not recorded	Malvaceae	Un-Shrub	Occassional
279	*Pavonia zeylanica Cav.*	Kuruntotti	Malvaceae	Un-Shrub	Occassional
280	*Pedalium murex L.*	Aanai nerunji	Pedaliaceae	Herb	Occassional
281	*Pedilanthus tithymaloides (L.) Poit.*	Kannatikkalli	Euphorbiaceae	Herb	Rare
282	*Peltophorum pterocarpum (DC.) K.Heyne.*	Ivalvagai	Caesalpinaceae	Tree	Rare
283	*Pentatropis capensis (L. f.) Bullock.*	Uppilan koti	Asclepidaceae	Climber	Occassional
284	*Pergularia daemia (Forssk.) Chiov.*	Velipparuthi	Asclepidaceae	Climber	Occassional
285	*Perotis indica (L.) Kuntze.*	Kudiraival pullu	Poaceae	Herb	Common
286	*Phoenix loureiroi Kunth.*	Sittreechu	Arecaceae	Shrub	Rare
287	*Phyla nodiflora (L.) Greene.*	Poduthalai	Verbenaceae	Herb	Rare
288	*Phyllanthus emblica L.*	Nelli	Euphorbiaceae	Tree	Rare
289	*Phyllanthus acidus (L.) Skeels.*	Aranelli	Euphorbiaceae	Tree	Rare
290	*Phyllanthus amarus Schum. & Thenn.*	Kilanelli	Euphorbiaceae	Herb	Occassional
291	*Phyllanthus debilis Klein Ex Willd.*	Not recorded	Euphorbiaceae	Herb	Occassional
292	*Phyllanthus maderaspatensis L.*	Melanelli	Euphorbiaceae	Herb	Occassional
293	*Phyllanthus reticulatus Poir.*	Civappu-puppilanji	Euphorbiaceae	Shrub	Occassional
294	*Phyllanthus virgatus G.Forst.*	Kadugu nelli	Euphorbiaceae	Herb	Occassional
295	*Physalis minima L.*	Sodakku thakkaali	Solanaceae	Herb	Occassional

296	*Pistia stratiotes L.*	Kodi-tamarai	Araceae	Herb	Occassional
297	*Pithecellobium dulce (Roxb.) Benth.*	Kotukkay puli	Mimosaceae	Tree	Rare
298	*Plumbago zeylanica L.*	Vencittiramulam	Plumbaginaceae	Herb	Occassional
299	*Plumeria rubra L.*	Arali	Apocynaceae	Shrub	Rare
300	*Polyalthiya longifolia (Thonn.) Thwatters.*	Nettulingamaram	Annonaceae	Tree	Rare
301	*Polycarpaea corymbosa Lam.*	Pallippuntu	Caryophyllaceae	Herb	Occassional
302	*Polygala arillata Buch.-Ham. ex D. Don*	Not recorded	Polygonaceae	Herb	Rare
303	*Polypodium quercifolium L.*	Iruvi	Polygonaceae	Herb	Rare
304	*Pongamia pinnata (L.) Pierre.*	Pungammaram	Fabaceae	Tree	Occassional
305	*Portulaca oleracea L.*	Paruppuukkirai	Portulacaceae	Herb	Occassional
306	*Premna corymbosa Rottler & Willd.*	Kulmunnai	Verbenaceae	Tree	Occassional
307	*Prosopis juliflora (Sw.) DC.*	Vellikkaruvai	Mimosaceae	Tree	Common
308	*Prunus dulcis (Miller) D.A. Webb.*	Vatamkottai	Rosaceae	Tree	Rare
309	*Pterolobium hexapetalum (Roth.) Santapau & Wagh.*	Karu indu	Ceasalpinaceae	Str-Shrub	Occassional
310	*Pupalia lappacea (Linn.) Juss.*	Aadai-otti	Amaranthaceae	Herb	Rare
311	*Rhinacanthus nasutus (L.) Kurz.*	Nagamalligai	Acanthaceae	Un-Shrub	Rare
312	*Riccia sorocarpa L.*	Not recorded	Ricciaceae	Herb	Common
313	*Ricinus communis L.*	Aamannukku	Euphorbiaceae	Shrub	Occassional
314	*Ruellia rivularis (Benoist) Boivin ex Benoist.*	Coracakkicceti	Acanthaceae	Herb	Occassional
315	*Ruellia tuberosa L.*	Tapas kaaya	Acanthaceae	Herb	Occassional
316	*Saccharum spontaneum L.*	Naanal	Poaceae	Herb	Occassional
317	*Sacciolepis indica (L.) Chase.*	Pullu	Poaceae	Herb	Occassional
318	*Sansevieria roxburghiana Schult. & Schult.f.*	Marul	Agavaceae	Herb	Occassional
319	*Sapindus trifoliatus L.*	Ponnangottai	Sapindaceae	Tree	Rare
320	*Sarcostemma acidum (Roxb.) Voigt.*	Kodikalli	Asclepiadaceae	Climber	Occassional
321	*Schoenoplectiella articulata (L.) Lye.*	Not recorded	Cyperaceae	Herb	Occassional
322	*Schoenoplectiella lateriflora (J.F.Gmel.) Lye*	Not recorded	Cyperaceae	Herb	Common
323	*Scopharia dulsis L.*	Sarakkotthini	Scrophulariaceae	Herb	Occassional
324	*Securinega leucopyrus (Willd.) Muell.-Arg.*	Vellaipoola	Euphorbiaceae	Shrub	Occassional

325	*Senna alexandrina Mill.*	Nilavagai	Caesalpiniaceae	Shrub	Rare
326	*Senna auriculata (L.) Roxb.*	Aavarai	Caesalpiniaceae	Shrub	Occassional
327	*Senna obtusifolia (L.) H.S.Irwin & Barneby.*	Oosithagarai	Caesalpiniaceae	Shrub	Occassional
328	*Senna occidentalis (L.) Link.*	Thappathagarai	Caesalpiniaceae	Shrub	Rare
329	*Senna timoriensis (DC.) H.S.Irwin & Barneby.*	Pagaditangedu	Caesalpiniaceae	Shrub	Rare
330	*Sesbania grandiflora (L.) Poiret.*	Agatthi	Fabaceae	Tree	Rare
331	*Sesbania sesban (L.) Merr.*	Sitthagathi	Fabaceae	Tree	Rare
332	*Setaria italica (L.) P.Beauv.*	Paintinai	Poaceae	Herb	Occassional
333	*Sida acuta Burm.f.*	Malaitangi	Malvaceae	Un-Shrub	Common
334	*Sida cordifolia L.*	Nilaththuthi	Malvaceae	Un-Shrub	Common
335	*Sida rhombifolia L.*	kuruntotti	Malvaceae	Un-Shrub	Occassional
336	*Solanum americanum Mill.*	Manathakkaali	Solanaceae	Herb	Occassional
337	*Solanum surattense Burm. f.*	Kandangkathiri	Solanaceae	Herb	Rare
338	*Solanum torvum Swartz.*	Sundai	Solanaceae	Shrub	Rare
339	*Solanum trilobatum L.*	Thuthuduvelai	Solanaceae	Trailer	Rare
340	*Solanum virginianum L.*	Kandangkathiri	Solanaceae	Herb	Rare
341	*Sopubia delphinifolia G. Don.*	Not recorded	Scrophulariaceae	Herb	Rare
342	*Spermacoce hispida L.*	Nathaichuri	Rubiaceae	Herb	Common
343	*Spermacoce articularis L.f.*	Nathaichuri	Rubiaceae	Herb	Common
344	*Sphaeranthus indicus L.*	Kottaikaranthai	Asreraceae	Herb	Common
345	*Sterculia foetida L.*	Peenaarimaram	Stericulaceae	Tree	Rare
346	*Streblus asper Lour.*	Pirayamaram	Moraceae	Tree	Rare
347	*Striga angustifolia (D. Don) C.J. Saldanha.*	Vellai ıkutakappuntu	Orobanchaceae	Herb	Occassional
348	*Striga asiatica (L.) Kuntze.*	Manjal ıkutakappuntu	Orobanchaceae	Herb	Rare
349	*Strychnos nux-vomica L.*	Kaanjarai	Loganiaceae	Tree	Occassional
350	*Strychnos potatorum L.*	Thettrangkottai	Loganiaceae	Tree	Occassional
351	*Syzygium cumini (L.) Skeels.*	Naval	Myrtaceae	Tree	Rare
352	*Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult. (L.) Burkill.*	Nanthiyavattai	Apocynaceae	Tree	Rare
353	*Tabernaemontana coronaria R.Br.*	Adukku	Apocynaceae	Shrub	Rare

		iyavattai			
354	*Tagetus erecta L.*	Thulankanchevanthi	Asteraceae	Herb	Rare
355	*Tamarindus indica L.*	Puliammaram	Ceaslpinaceae	Shrub	Occassional
356	*Tecoma stans (L.) Juss. ex Kunth.*	Ponnarali	Bignoniaceae	Shrub	Rare
357	*Tectona grandis L.F.*	Thekku	Verbenaceae	Tree	Rare
358	*Tephrosia purpurea Pers.*	Kolunji	Fabaceae	Tree	Common
359	*Tephrosia villosa Pers.*	Vayakkavalai	Fabaceae	Herb	Occassional
360	*Thespesia populnea (L.) Sol.Ex. Correa.*	Poovarasu	Malvaceae	Herb	Rare
361	*Thevetia peruviana Merril.*	Manjal Arali	Apocynaceae	Tree	Rare
362	*Tinospora cordifolia (Willd.) Miers.*	Shindilakodi	Menispermaceae	Shrub	Occassional
363	*Toddalia asiatica (L.) Lam.*	Milagaranai	Rutaceae	Climber	Occassional
364	*Tragia involucrata L.*	Senthetti	Euphorbiaceae	Woody liana	Occassional
365	*Trianthema portulacastrum L.*	Saranikeerai	Caesalpiniaceae	Shrub	Occassional
366	*Tribulus terrestris L.*	Nerunjil	Zygophyllaceae	Herb	Common
367	*Trichodesma indicum R.Br.*	Kavilthumbai	Boraginaceae	Herb	Occassional
368	*Tridax procumbens L.*	Vettukkayapoondu	Asteraceae	Herb	Common
369	*Triumfetta rhomboidea Jacq.*	Ataiyottippuntu	Tilliaceae	Herb	Occassional
370	*Tylophora indica (Burm.f.) Merrill.*	Nancaruppan	Asclepidaceae	Herb	Occassional
371	*Urginea indica (Roxb) Kunth.*	Kaattuvengayam	Hyacinthaceae	Climber	Rare
372	*Utricularia bifida L.*	Not recorded	Lentibulariaceae	Herb	Rare
373	*Utricularia reticulata Sm.*	Not recorded	Lentibulariaceae	Herb	Rare
374	*Vaccaria pyramidata Medic.*	Kilapalam	Caryophyllaceae	Herb	Occassional
375	*Vernonia cinerea (L.) Less.*	Neichattipoondu	Asteraceae	Herb	Common
376	*Vicoa indica (L.) DC.*	Jimikipoo	Asteraceae	Herb	Common
377	*Vigna trilobata (L.) Verdcourt.*	Nari payaru	Fabaceae	Herb	Rare
378	*Vitex negundo L.*	Notchi	Verbenaceae	Climbing herb	Occassional
379	*Waltheria indica L.*	Not recorded	Stericulaceae	Un-Shrub	Occassional
380	*Wattakaka volubilis (L.F.) Stapf.*	Perunkurinja	Asclepidaceae	Shrub	Rare
381	*Wrightia tinctoria (Roxb.) R.Br.*	Veppalai	Apocynaceae	Climber	Common
382	*Xanthium strumarium L.*	Marulumathai	Asteraceae	Tree	Occassional

383	*Ziziphus mauritiana Lam.*	Elanthai	Rhamnaceae	Tree	Occassional
384	*Zizyphus oenoplia (L.) Miller.*	Soorai	Rhamnaceae	Tree	Common
385	*Zornia gibbosa Span.*	Not recorded	Fabaceae	Tree	Rare

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RESEARCH ARTICLE

Land Use/Land Cover Mapping of Maharajasamudram River Watershed, Coastal Tamil Nadu, India Using Remote Sensing Data

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ABSTRACT

An attempt has been carried out to map the land use and land cover categories of Maharajasamudram river watershed, using remote sensing data. The total area of the watershed is 1078 sq. Km. and it is located in the east coast of Tami Nadu. Land use/land cover map were generated and the areas were categorized into built-up land, agricultural land (crop land, fallow/harvested land, agricultural plantation), forest (dense and degraded forests), wastelands, land with scrub, barren rocky areas, sandy areas, saltpan and salt affected areas, waterlogged marsh land, water bodies and other (pasture land) on the basis of NRSA classification. Agricultural land (crop land and agricultural plantation), built-up lands and wastelands were dominant in the watershed, which were about 695 sq. Km. (64%) 171sq.Km. (16%) and 100 sq. Km (9%) respectively. The significance of such a study in the formulation of management plans/developed plans is also discussed.

Key words: Land use, Land cover, Remote Sensing, NRSA

INTRODUCTION

Land is one of the most important natural resources on which man's activities are based. Ever growing population and human activities are increasing the demand on our limited land resources. Man utilizes land for various purposes like settlement, agriculture forest, urban development, industrial activities etc. Therefore to meet the demand of land reliable, comprehensive and up to date information on the present land use is required. This can be obtained from the remote sensing data.

The purpose of land/land cover study is to know the different uses of land, to maximize the productivity and to conserve the land for prosperity. Physical factors and human activities are the two main factors influencing the pattern of land use (Mishra1990). Physical features include topography, climate and soil which set the broad limits upon the capabilities of the land, while the human factors like length of occupation of area, density of population, social and economic factors especially the system of land tenure and technological levels of the people determine the extent to which the physical capacities of land area utilized (Dube R.N and Negi. B.1988).

Study Area

The Maharajasamudram watershed forms a part of the Cauvery basin and comprises of the catchment of the Maharajasamudram and its tributaries. This watershed falls in two districts of the state of TamilNadu namely Thanjavur and Pudukottai. It is partially in the eastern part of Pudukottai and partially in the south western part of Thanjavur. Roughly shaped like a knife, having spatial extent of 62 km in length (North West to south east direction) and 28 km width (north- to south direction) in Thanjavur and Pudukottai district, Tamil Nadu, covering an area of 1078sq km. The Blocks covered by the watershed are Kunnandarkoil Pudukottai, Thanjavur, Gandarvakottai, Orathanadu, Thiruvonam, Karambakudi, Madukkur, Peravurani and Pattukottai. The watershed includes 4 taluks from Thanjavur and 4 taluks from Pudukottai. The taluks are Kulathur, Pudukottai, Alangudi, Gandarvakottai, Thanjavur, Orathanadu, Pattukottai, and Peravurani. The watershed comprises of 210 villages.

The Study Area is situated between Parallels of 10^{o} 17' 42.31''N To 10^{o} 42' 52.62''N and 78^{o} 55' 21.51''E To 79^{o} 25' 31.72''E. (Fig.1) The watershed may be classified as non delta region (west) delta region (east) and coastal region (south east).The general slope of the land is from NW to SE (120 m to 40 m) from MSL. Geologically most of the rocks fall under Caddalor sand stone .Caddalor sand stone is 88 per cent (937 sq. km) of the total geographical of the watershed. The Fluvio marine Sediments covers 94 sq.km (8.8 per cent) in south eastern part of the watershed. The Madukkur soil series occupied 56.4 per cent of the area followed by Pattukottai (28.9 per cent). Peravurani soil series was the least which accounted for only 0. 39 per cent. The mean annual rainfall of this watershed is 685 mm. The watershed receiving maximum rainfall during north east monsoon (October to November) and minimum during Winter Monsoon. The intensity and amount of rainfall are unpredictable during south west monsoon period (June to September) The period between January to May is the main dry season.

MATERIALS AND METHODS

The study has made use of various primary and secondary data. These include Survey of India (SOI) topographic maps. (58 J/14, 58 N/2, 58 N/2, 58 N/3, and 58 N/7 on 1:50,000 scale) and IRS LISS-III Geocoded data of 1:50,000 scale for April-2009.The Indian Remote Sensing Satellite (IRS) were visually interpreted by using image interpretation elements such as tone, texture, shape, pattern, association etc. Adequate field checks were made before ascertaining/finalizing of the thematic maps.

Land Use/Land Cover

Remote sensing technology has made significant contribution in the area of land use mapping. The land use /land cover categories of the study area are mapped using IRS LISS III data of 1:50,000 scale. The satellite data is visually interpreted and after making a through field check, the map is finalized (Fig.2).The various land use/ land cover classes, interpreted further the study area include, built-up land, agricultural land (crop land, fallow/harvested land, agricultural plantation), forest (dense and degraded forests), wastelands, land with scrub, barren rocky areas, sandy areas, saltpan and salt affected areas, waterlogged marsh land, water bodies and other (pasture land). A detailed account of these land use / land cover classes of the study area are described in the following section on the basis of the NRSA standard classification system.

RESULTS AND DISCUSSION

a. Built up Land

The built up lands include all residential, commercial, and industrial development. These features are identified with their dark bluish green tone in the core and bluish tone in the periphery. They have a typical coarse and molted texture. These areas are also associated with net work of canals, roads, and railway lines.

Built up land occupied by human settlement covers an area of 171 sq. Km constituting 16% of the total area of the watershed. The built up land constitutes villages and settlements, and town and cities. There 210 villages in this watershed. Pattukottai town comes under this watershed. Few smaller settlements are mapped include Adhirampattinam, Rajamadam,Karambakudi, Vettikadu, Tiruvonam, Tirunallar,Pachur, Eachankottai.

b. Agricultural Land

The land is mainly used for farming of food grains, commercial and horticultural Crops are called agricultural land. With the help of satellite data, it is possible to identify various agricultural land uses up to level II. Various categories of agricultural lands identified in the study area are described below in detail.

i) Crop land

Crop land is used for the production of adapted crops, like wheat, paddy and horticultural crops. As such, it is landscape created by humans and is no longer part of the natural ecology. These include all the agricultural areas identified by their characteristic red tone, regular shaped agricultural fields and in association with settlements, water bodies, etc. The crop lands are found well distributed in the new delta region of the watershed. The kharif crops (paddy, groundnut, sorghum, red gram, black gram, and green gram horse gram, caster gingerly and sunflower) are cultivated in the months of June, July and August. The rabi crops (paddy, surghm, maize, black gram green gram, groundnut, sunflower, gingerly, sugarcane) are cultivated in the month of October, November and December. These crops are cultivated throughout the study area and it occupies 444 sq. Km. or (41 per cent) of this total study area.

ii) Fallow land

These are the lands which remains vacant without crop cultivation. These are identified by their dark greenish tone, smaller size, regular shape and medium texture. These fallow lands are found in the upland and tail end areas of the study area and in other areas they are scattered. These occupy by 65 sq. Km. (11.5 percent) of the study area.

iii) Plantations

Plantation crops such as coconut, mango, sapotta, guava,etc. Cachewnut are the major crops cultivated in the watershed. Such areas are identified from their dark and red tone, medium texture and are found in the upland and tail end region of the study area. Coconut plantation is predominant in new deltaic tail end region. Pattukottai and Peravurani taluk leads in coconut plantation. Cachewnut is the most important commercial crop in the watershed. Gandarvakottai, Pudukottai, Kunnandarkoil and karambakudi blocks have contributed 99 per cent of the total area under this crop in the watershed.

c. Forest

Forest comprises thick and dense canopy of tall trees. These lands are discerned by their red to dark red tone and varying sizes. They show irregular shape and smooth texture. These forest areas are found on the north western part of the watershed. The areas under these categories cover about 15 sq. Km. (2 per cent).

d. Waste Lands

Waste land may be defined as that land which has been previously used but which been abandoned and for which further use has been found Dudly Stamp (1954). Wasteland survey and reclamation committee Ministry of food and agriculture (1961) has defined waste land as these lands, which are either not available for cultivation or left out without being cultivated, like fallows and culturable waste. Society for promotion of waste land development has defined wasteland, those lands are waste lands which are a) ecologically unstable e) whose top soil has been nearly completely lost and c) which has developed toxicity in the root zones for growth of most plants, both annual crops and trees. National remote sensing Agency (NRSA-1985) defined waste land as that land which is presently lying unused or which is not being used to its optimum potential due to some constraints. Different types of waste land category are identified based on their image characteristics like tone, texture, pattern shape, size, location and association.

i) Land with Scrub

These lands with scrub are generally prone to deterioration and may or may not have scrub cover. The lands under this category are confined to the upland areas of the watershed. These lands occur in the north west of the watershed. Parts Gandarvakottai, Kulathur, Pudukottai and Thanjavur blocks comes under this category. The areas under this class cover about 42 sq.km. (4 per cent)

ii) Barren Rocky

It is an area of rocky exposure of varying lithology often barren and devoid of soil and vegetation cover. In the study area, these lands appear as brownish colour is easily identified in the image. The area under this class is 10 sq.km (1 per cent).

iii) Salt affected Lands

The salt affected lands are generally characterized as the lands that have adverse affect on the growth of most plants. These occur mainly in inland plains as white patches and are can easily identified in the image. The area under this category 17sq.km.(2 per cent).

iv) Waterlogged Marsh Land

Marsh lands are observed in the coastal area of the watershed. The area occupies about 16 sq.km. (1 per cent) Waterlogged areas are scattered in this study area.

v) Sand/Inland/Coast and Mining

These types of lands are found in interior as well as coastal area of the watershed. Along the riverbeds sand mining occur. This category covers 15 sq.km. (1 per cent).

e) Water Bodies

Water bodies are the areas of impounded water in tanks, reservoirs etc. and have regulated floe of water from either rivers or canals. Deep water appears as light blue tone. The major rivers of the study area are Maharajasamudram and Grand Anaicut. The other minor rivers are Vadakadu, Nasuvini,Naduvikottai, Olavayal, Kattar. There is no major reservoir as such in the study area. However numerous major and minor tanks are identified. Lakes and tanks are found scattered throughout the watershed, except the tail head area of the new deltaic region. The area under this category covers 31 sq.km. (3 per cent). (Fig. 3)

f) Pasture and grazing land

The south western part of the study area covering river banks and adjacent area comes under this land category. The area under this class is 1sq.km. (0.11 per cent) it is a very negligible.

CONCLUSION

The land use categories of the study area were mapped with help of IRS data. the land use categories were demarcated as built- up land, agricultural land (crop land, fallow land, agricultural plantation, forest (dense and degraded forests) wastelands, land with scrub, barren rocky areas, sandy areas, saltpan and salt affected areas, waterlogged marsh land, water bodies and other (pasture land). The built-up lands in the study area include towns /minor towns and villages; the total area covered under this land use category is about 171 sq.km. (Table.1).Among the agricultural lands, it was possible to identify the crop lands, fallow lands and plantations. Agricultural areas were found well distributed throughout the study area for the reason that most of the people engaged in agricultural activities. Total area covered by this land use category is about 695 sq.km, out of 1078 sq.km of the watershed (70 per cent).

The forests of the study area are confined to the north western part of the study area. The forests occupy about 15 sq.km.Waste land categories, such as land with scrub, barren rocky areas, sandy areas, saltpan and salt affected areas, waterlogged marsh land areas were demarcated. The lands with scrub or without scrub were found near vallam up land. The salt affected areas found in the inland plains. Salt pan is in the coast of study area. It occupies about an area of 100 sq.km. in the study area. The water body category, features such as rivers/streams, tanks and reservoirs were delineated. There are no reservoirs in the study area however, numerous major and minor tanks were identified some of them are dry. The tanks spread entire study area and cover about. The water bodies cover about 31sq.km.The mapping of the land use /land cover is useful for present status of land use analysis, planning and decision making process.

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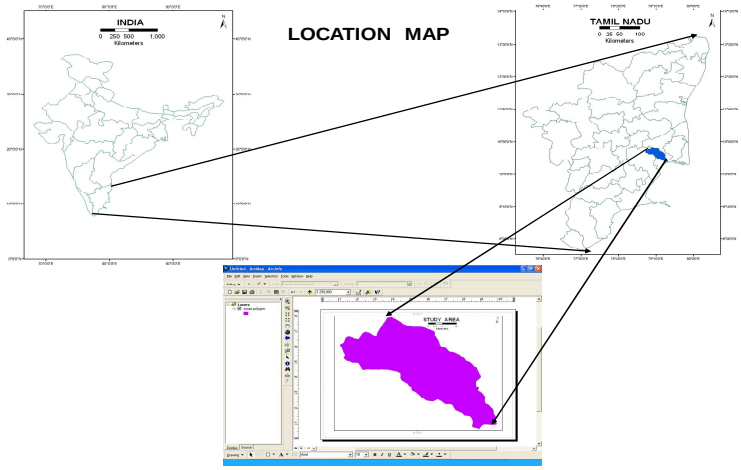

Fig.1 **Study area**

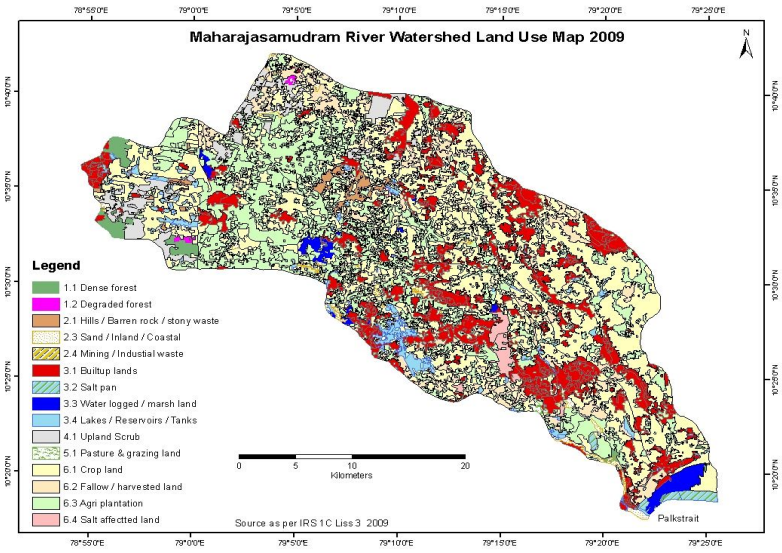

Fig.2.Land Use/Land Cover

Table 1: Land Use/ Land Cover Classification of Maharajasamudram River watershed

SL.No	Level I	Level II	Area in sq.Km	Percentage of Watershed Area
1	Built up Land	Built up lands	171	16
2	Agricultural Land	Crop land	444	41
		Fallow/harvested land	65	6
		Agricultural Plantation	251	23
3	Forest	Dense forest	14	1
		Degraded forest	1	0.1
4	Waste lands	Barren rocky/stony waste	10	1
		Sand/Inland/Coastal	15	1
		Mining waste	0.4	0.4
		Salt pan	6	1
		Salt affected land	11	1
		water logged/marsh land	16	1
		Upland scurb	42	4
5	Water Bodies	River/strem/lake/tank/canal/	31	3
6	Others	Pasture/grazing land	1	0.11
Total			1078	100

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RESEARCH ARTICLE

Computational Analysis of Selected Drugs Based on Lipinski's rule and Distribution of Amino acids for Canavan Disease

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ABSTRACT

Canavan disease is an autosomal recessive degenerative disorder (one of the group of genetic disorders called "leukodystrophies") that causes progressive damage to nerve cells in the brain. We have analyzed the distribution of amino acids comparatively in Canavan disease and some other genetic disorders to identify the amino acids composition. Also demonstrating that the calculation of drug parameters for various drugs treated for Canavan disease. We have done some systematic studies on the collected drugs for Canavan disease based on Lipinski's rule of five. Amino acid distribution analysis clearly shown that polar amino acids is abundantly seen in all kind of genetic disorder whereas in Canavan disease hydrophobic amino acid is predominantly present in addition with polar amino acids. Drug parameter calculation found that there are some variations occurred in drug parameters of each drugs and it may leads to different kind of functions. On the basis of Lipinski's rule we have predicted that Ropinirole has the good absorption capacity when compared with other drug compounds and it is the best curing agent for Canavan disease.

Keywords: Canavan disease, Drug parameters, Lipinski's Rule, Log P Value.

INTRODUCTION

Polarity of the amino acid side chain determines its characteristics, e.g., hydrophilic or hydrophobic character. These properties are important in protein structure and protein-protein interactions. The importance of the physical properties of the side chains comes from the influence this has on the amino acid residues' interactions with other structures, both within a single protein and between proteins. The distribution of hydrophilic and hydrophobic amino acids determines the tertiary structure of the protein, and their physical location on the outside structure of the proteins influences their quaternary structure [1, 2]. The structure of protein is typically important because the protein functions evolve and defined by their concern protein structure.

Canavan Disease

Canavan disease is an autosomal recessive degenerative disorder that causes progressive damage to nerve cells in the brain. This disease is one of a group of genetic disorders called leukodystrophies. Leukodystrophies are characterized by degeneration of myelin in the phospholipid layer insulating the axon of a neuron. The gene associated with the disorder is located on human chromosome 17 [4]. Elevations of the levels of N-acetyl-aspartyl-glutamate (NAAG) and N-acetyl-aspartate (NAA) are associated with myelin loss in the leucodystrophies Canavan's disease and Pelizaeus-Merzbacher-like disease. NAAG and NAA can activate and antagonize neuronal N-methyl-D-aspartate (NMDA) receptors, and also act on group II metabotropic glutamate receptors. Oligodendrocytes and their precursors have recently been shown to express NMDA receptors, and activation of these receptors in ischaemia leads to the death of oligodendrocyte precursors and the loss of myelin [5].

Symptoms, Treatment, and Prognosis

Symptoms of Canavan disease, which appear in early infancy and progress rapidly, may include mental retardation, loss of previously acquired motor skills, feeding difficulties and abnormal muscle tone [3]. There is no cure for Canavan disease, nor is there a standard course of treatment. Treatment is symptomatic and supportive. Death usually occurs before age 4 without treatment. Some children may survive into their twenties via newer gene therapy treatments which have extended their life expectancy. In some cases, this helps to temporarily stop the progression of the disease [6, 7].

Lipinski's Rule-of-Five

Christopher Lipinski's rule-of-five analysis helped to raise awareness about properties and structural features that make molecules more or less drug-like. The guidelines were quickly adopted by the pharmaceutical industry as it helped apply ADME considerations early in preclinical development and could help avoid costly late-stage preclinical and clinical failures. The guidelines predict that poor absorption or permeation of a orally administered compound are more likely or not depends upon the defined criteria.

The Rule of 5" got its name from the cutoff values for each of the four parameters that define the "drug-likeness" of the potential drug candidates: all of these values are close to five or a multiple of five. In the USAN set we found that the sum of Ns and Os in the molecular formula was greater than 10 in 12% of the compounds. Eleven percent of compounds had a MWT of over 500. Ten percent of compounds had a CLogP larger than 5 (or an MLogP larger than 4.15) and in 8% of compounds the sum of OHs and NHs in the chemical structure was larger than 5. The "rule of 5" states that: poor absorption or permeation is more likely when:

- There are more than 5 H-bond donors
- The MWT is over 500
- The Log P is over 5
- There are more than 10 H-bond acceptors

MATERIALS AND METHODS

Protein sequence collection and amino acid composition analysis

Protein sequences for genetic disorders collected from NCBI. The sequences were saved in notepad and submitted in to C Program. Amino acid compositions for all the disorder sequences are calculated using C program. The values are stored in the MS-Excel and Graph drawn for all types of amino acids and genetic disorders.

Drug parameter calculation

The list of drugs were retrieved from drug bank for each Genetic Disorders. Based on Lipinski's rule the parameters are calculated like Hbond donor, Hbond acceptor, Log P and Molecular weight. Hbond donors, Hbond acceptors and Mol.wt were calculated by Pubchem compound database and Log P values calculated by ALOGPS tool. A shared feature pharmacophore was also constructed that shows four common features (one hydrogen bond Donar, two hydrogen bond Acceptor and one ionizable area) help compounds to interact with this enzyme. It was predicted similar orientation and binding modes for these compounds with L-739 in FTase [8].

The electrophilicity index, molecular polarizability, the averages of the negative potentials on the molecular and the balance parameter of surface potential were the key parameters governing the log values in the QSAR model, which indicated that the log k (d) value was mainly related to the partition ability, electrostatic interactions, and van der Waals interactions of compounds[9].

At neutral pH was entirely dependent on the molecular mass of the dextran. Low-molecular-mass (10 and 20 kDa) dextrans were completely released in 12 and 21 days, respectively, while high-molecular-mass (≥40 kDa) dextrans being continuously released over 36 days, indicating that the threshold of molecular weight necessary for sustained release of a hydrophilic macromolecule[10].

RESULTS

TABLE 1: DISTRIBUTION OF AMINO ACIDS IN CANAVAN DISEASE

Genetic disorder	Hydrophobic amino acids	Hydrophilic amino acids	Polar amino acids	Nonpolar amino acids
Canavan Disease	26.426668	11.986665	19.333335	15.044443

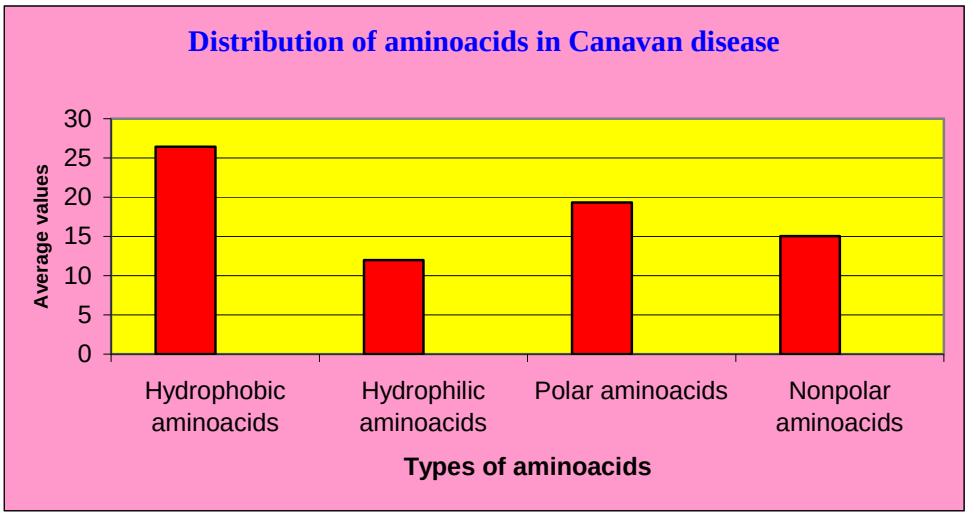

Table 1 and Figure 1 show the amino acid distribution of canavan disease. In canavan disease hydrophobic amino acids is highly present when compared with other amino acids such as hydrophilic, polar and nonpolar amino acids

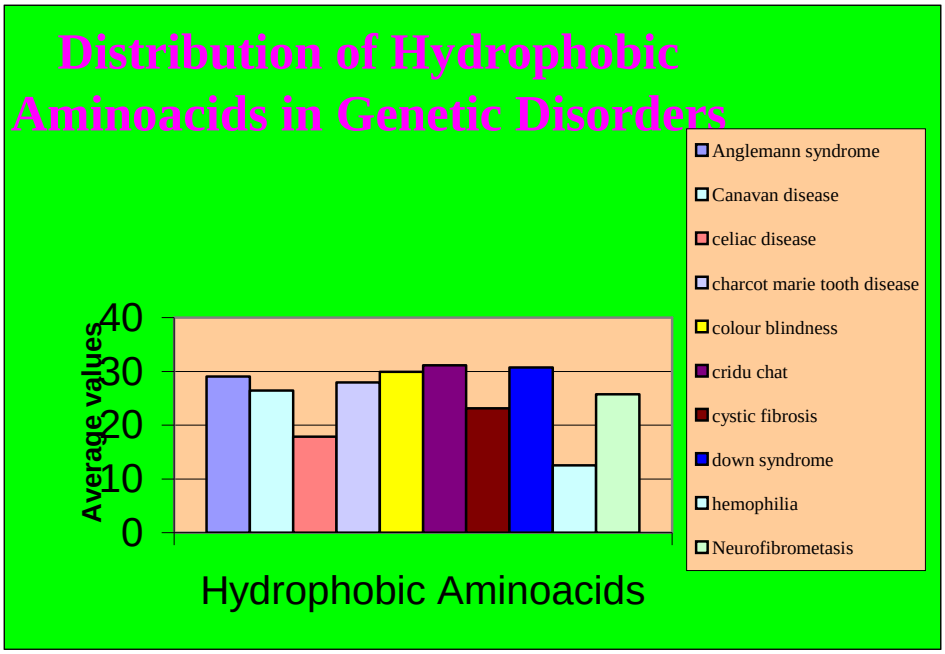

Fig 1: Distribution of Hydrophobic amino acids in Genetic Disorders

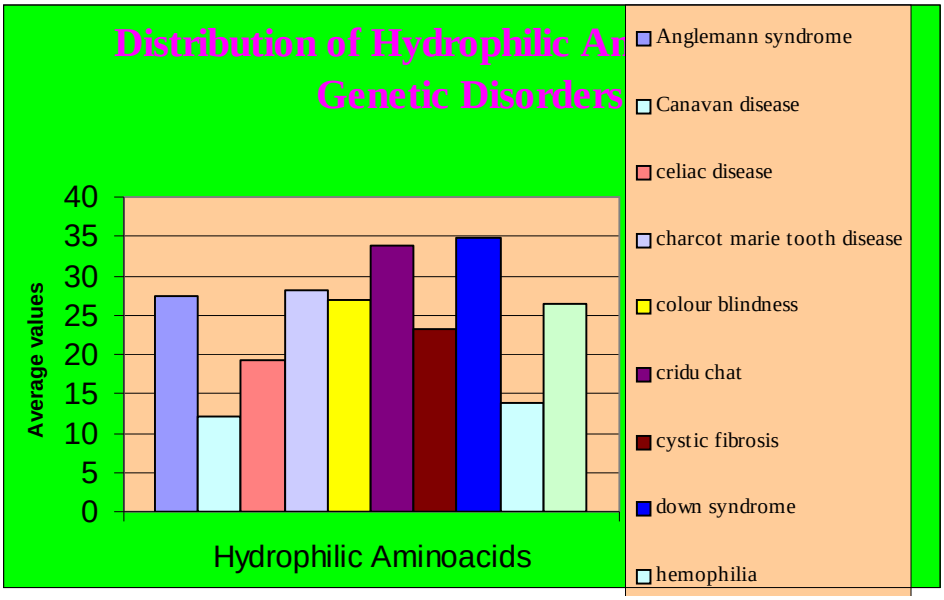

Fig 2: Distribution of Hydrophilic amino acids in Genetic Disorders

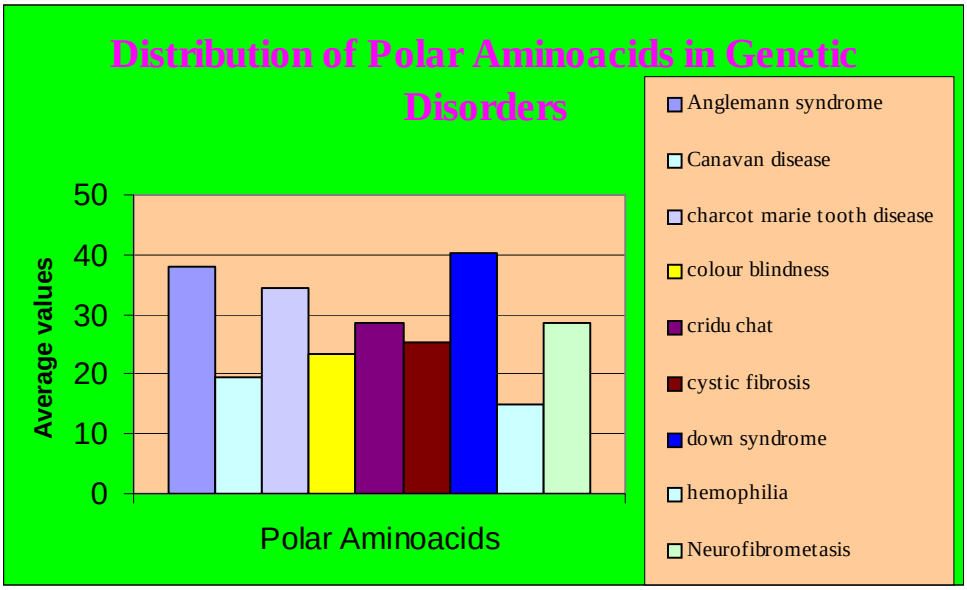

Fig 3: Distribution of Polar amino acids in Genetic Disorders

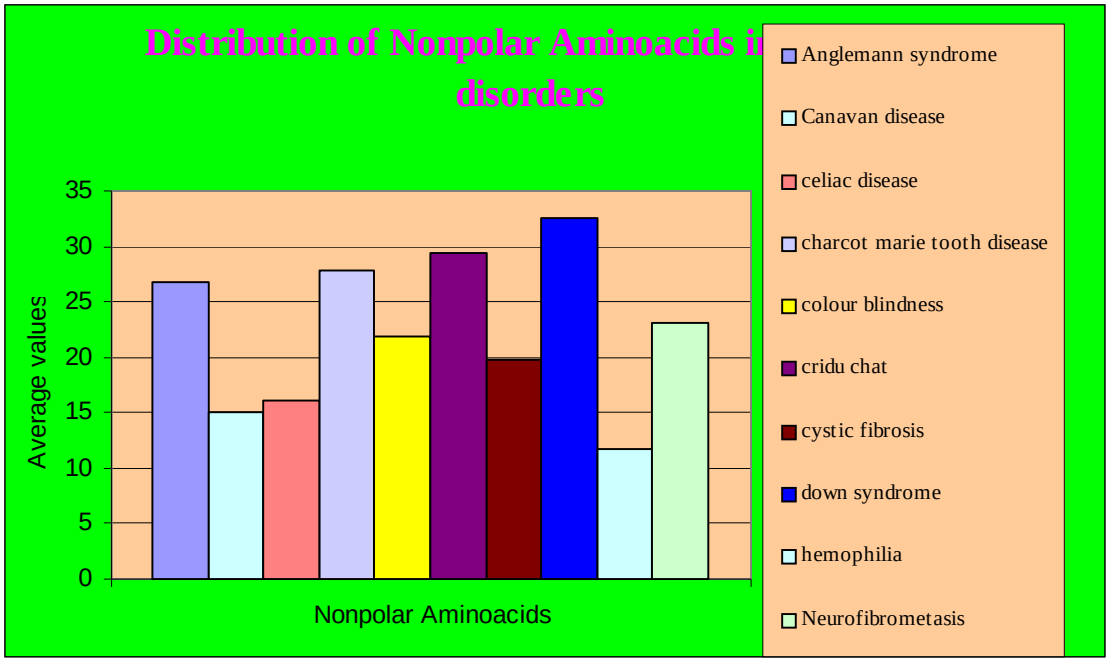

Fig 4: Distribution of Non Polar amino acids in Genetic Disorders

In all Genetic Disorders such as Anglemann syndrome, Canavan disease, Celiac Disease, Charcot Marie Tooth disease, Colour Blindness, Cridu chat Syndrome, Cystic Fibrosis, Down syndrome, Hemophilia and Neurofibrometasis, the distribution of Hydrophobic (Fig. 2), Hydrophilic (Fig. 3) and Non Polar (Fig. 5) amino acids are very low when compared with Polar amino acids (Fig. 4).

TABLE 2: CALCULATION OF DRUG PARAMETERS FOR CANAVAN DISEASE

Drugs	Hbond Donar	Hbond Acceptor	Log P	Mol.wt
Olsalazine	4	8	1.13	302.239
Penicillamine	2	3	-1.70	149.211
Ropinirole	1	2	3.16	260.374
Entacapone	2	6	2.50	305.286
Mesalazine	2	4	0.15	152.127

According Lipinski rule of five we stated that the drug should contain very low amount of H-bond donors and H-bond acceptors, also the molecular weight and log P value must be minimum. Table 2 shows the drug parameters such as Hbond Donar, Hbond Acceptor, Log P value and Mol.wt for the drugs Olsalazine, Penicillamine, Ropinirole, Entacapone and Mesalazine.

TABLE 3: ABSORPTION ANALYSIS FOR CANAVAN DISEASE

Drugs	A	B	C	D	Absorption
Olsalazine	0	0	0	0	Poor
Penicillamine	0	0	0	0	Poor
Ropinirole	0	0	1	0	Good
Entacapone	0	0	0	0	Poor
Mesalazine	0	0	0	0	Poor

Absorption or permeation is an essential process for the distribution, Metabolism, Excretion and Toxicology of drug compounds. Table 3 shows absorption analysis of drugs for canavan disease. Absorption or permeation analysis grades the drug whether it is having good or poor capacity for absorption.

CONCLUSION

Generally polar amino acids are highly distributed in all kind of genetic disorders (Figures 2–5). In canavan disease, in addition to the polar amino acid (19.333335, Table 1), hydrophobic amino acids (26.426668, Table 1) are abundantly present. (Fig. 1). From the normal sequence, the amino acids are mutated to Aspartic acid and Glutamic acid. The mutation, which converts the non-polar amino acids to Polar, Hydrophobic and Hydrophilic Residues. Due to the above reason, genetic disorders may be caused. If the amino acids are not mutated to Hydrophobic, Hydrophilic or polar amino acids, we can reduce the risks of genetic disorders. If we increase the non-polar amino acids, we may control the genetic disorders. The drugs which satisfy the Lipinski's rule and it have a good absorption capacity. Based on this we analyzed that Ropinirole has 1 Hbond Donar and 2 Hbond Acceptor (Table 2). Mesalazine has very low log P value (Table 2). Penicillamine has low molecular weight 149.211 (Table 2). From these observations we depicted that Ropinirole is the best drug for canavan disease out of the five collected drugs. As described earlier Lipinski's rule of "drug-likeness" directly leads us to predict the absorption capacity of the above-mentioned drugs. Finally, we concluded that Ropinirole has good absorption capacity (Table 3) when compared with other drugs.

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RESEARCH ARTICLE

Rainfall Analysis for Crop Planning in Semi Arid Region of Southern Telangana, India

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ABSTRACT

Indian economy is mainly depends on agriculture, which is based on monsoon rainfall and its distribution. Rainwater is the of the most import potential source of moisture for rain fed farming. The weekly, monthly and seasonal pattern and their probabilities helpful to crop planning by identifying the period of drought, normal and excess rainfall. Though the rainfall is erratic and varies with time and space, it is commonly possible to predict return period using various probability distributions Though the rainfall is erratic and varies with time and space, it is commonly possible to predict return period using various probability distributions Frequency analysis of rainfall data has been attempted for different places in India. The amount of rainfall received in Hyderabad of Ranaga Reddy district is adequate for rainfed farming in Kharif season. But cultivation in other season requires appropriate rainwater harvesting and their management, selection of crops and irrigation scheduling. The present study is undertaken for analyzing the distribution of rainfall characteristics for better planning in rain fed farming system.

Key words: Rain fed farming, crop management, sustainable production, moisture conservation.

INTRODUCTION

Indian economy is mainly depends on agriculture, which is based on monsoon rainfall and its distribution. Rainwater is the of the most import potential source of moisture for rain fed farming. Rainfall can determine the potential of any region especially in arid and semi arid areas, in terms of crop production activities, moisture conservation methods and farming system to be adopted, the nature and sequence of farming operation to be followed and to achieve high agricultural productivity (Singh and Dhillon, 1994). In dry land agricultural system the total amount of rainfall and its distribution affects the plant growth (Sharma et al., 1979, Ram Suresh et al., 1992).

Probability analysis is the most reliable method to predict occurrence of future rainfall events based on past behavior of rainfall (Kumar and Kumar, 1989). The weekly, monthly and seasonal pattern and their probabilities helpful to crop planning by identifying the period of drought, normal and excess rainfall (Ray et al., 1980). Though the rainfall is erratic and varies with time and space, it is commonly possible to predict return period using various probability distributions (Upadhaya and Singh, 1998). Frequency analysis of rainfall data has been attempted for different places in India (Jeevrathnam and Jaykumar, 1979; Sharda and Bhushan, 1985; Prakash and Rao,1986; Aggaerwal et al., 1988; Bhatt et al., 1996; Mohanty et al., 1999; Rizvi et al., 2001; Singh, 2001; Bhakar el at., 2006; Xeflide and Ophori , 2007; Bhakar et al., 2008; Barkotulla et al., 2009).Rainfall analysis is of great importance for developing and modifying the crop management practices for sustainable production.

The amount of rainfall received in Hyderabad of Ranaga Reddy district is adequate for rainfed farming in Kharif season. But cultivation in other season requires appropriate rainwater harvesting and their management, selection of crops and irrigation scheduling. The present study is undertaken for analyzing the distribution of rainfall characteristics for better planning in rain fed farming system.

MATERIALS AND METHODS

Hyderabad of Ranga Reddy Districts is situated in between 17^0, 40', 40.4''North latitude; and 78^0, 39', 55.7'' East longitude. The climate is Dry which receives an annual rainfall is about 750 mm and about 70 % of which occurs during monsoon (June to September i.e.500 mm).

Historical rainfall data were for 44 years (1967-2010) were collected from Indian Meteorological Department. The daily rainfall data were converted to weekly, monthly, seasonal, annual and decadal rainfall pattern were critically examined and analyzed by simple mathematical means. The standard deviation and coefficient of variation were also worked out.

Three seasons, viz. kharif (June-September), rabi (October – February) and summer (March to May) were identified according to existing rainfall of the corresponding month of the respective season was summed up for its probability analysis. Daily rainfall of respective year was summed up to calculate yearly rainfall and average was calculated by dividing the yearly total rainfall by total number of years. Rainy day is considered as rainfall of particular day if exceeds 2.5 mm. the analysis of drought was done as per Indian Meteorological Department Criteria as "mild", "moderate" and " severe" based on departure of actual rainfall from the average rainfall of the available data. If the rainfall departs up to 25% from average rainfall, it termed as mild drought; if the departure ranges between 25 to 50% from average rainfall, it is called moderate drought and if the departure ranges between 50 to 75% from the average rainfall, it is called as severe drought.

The probability analysis was carried out using Weibull's method (Chow, 1964), which is

$$P = \left(\frac{m}{N+1}\right) \times 100$$

Where, P is the plotting position in percent chance; m is the rank number when data are arranged in descending order and N is total number of years. The recurrence intervals (T) were calculated using the relationship $T=P^{-1}$.Jena and Senapati (1981) found that Weibull's equation approximately closely the linear relationship between rainfall and plotting positions than the other equations.

RESULTS AND DISCUSSION

The average annual rainfall in this region was recorded 753.94 mm for the past 44 years (1967-2010) with a standard deviation of 216.093 mm and coefficient of variation 28.66%. The lowest average annual rainfall of 423.5 mm was observed during 1972, and region receives the highest rainfall of 1606.2 mm in the year 1975 (Fig.1). Among 44 year of rainfall record data it was observed that 23 years recorded the annual rainfall excess of average or normal (753.94 mm) while 26 years recorded below normal rainfall (Fig.2). A decrease trend in decadal average rainfall has been observed during past 44 years. The highest average rainfall of 805.99 mm was recorded during the decade (1967-1976) and the lowest average rainfall of 726.91 mm received during the decade (1997-2006) (Table 1). The annual rainfall pattern also showed that the frequency of droughts has been increased since the 1999 and region has faced continues drought up to 2002 (Table 2). The failure of occurrence of rainfall, which indicates that agricultural lands can neither provide work or nor livelihood to the farmers who are dependent on it.

Analysis of variability in seasonal rainfall

A year is divided into three season viz, monsoon or kharif season (June –September), winter or rabi season (October-February) and in pre-monsoon or summer season (March-May). The average seasonal variability during Kharif, rabi and summer season are presented in Table 3. It was observed that the highest rainfall received during the kharif season (505.95 mm). A major portion of it generally lost through runoff and infiltration, which can be stored through in-situ and ex-situ water harvesting structures and it can be used during kharif / rabi / summer for growing crops like groundnut, caster, redgram, green gram, maize, sorgum and vegetables etc. It can also be utilized as life saving irrigation particularly during dry periods, because a dry period of one or two weeks in rainy season may adversely affect the standing kharif crops in this region. The average rainfall received during rabi season is 165.77 mm and lowest in summer season of 88.22 mm. the percentage distribution of seasonal rainfall to the total was observed 67.11%, 21.99% and 10.91% during kharif, rabi and summer season respectively with the lowest coefficient of variation during kharif(29.70%) followed by summer (49.15%) and rabi (65.46%). During summer season (March – May) rainfall is on an average was observed that 82.22 mm which whould be helpful for summer ploughing operations.

Monthly and weekly Rainfall Variability

From statistical analysis of the 44 years monthly rainfall data (1967-2010) was observed that the monthly maximum average rainfall of 148.13mm in the month of September with standard deviation 105.95mm and coefficient of variation of 71.52 %, and lowest of 5.4 mm average monthly rainfall with standard deviation of 12.0 mm and coefficient of variation of 222.24 % during the month of December (Table 4). From the analysis it was also observed that 402.4mm monthly extreme rainfall event during October 1989.

Also the results obtained from statistical analysis of weekly rainfall (1967-2010) was observed that the mean maximum weekly rainfall of 40.99 mm during 39th week with 58.899 standard deviation and coefficient of variation of 143.69. lowest weekly average rainfall was observed during 1st week of 0.561 mm with Standard deviation of 0.561 and coefficient of variation 467.5 (Table 5) also from the analysis of weekly rainfall data was observed that 279.5mm weekly extreme rainfall event during 39th week in the year 1975.

Probability of rainfall

The past 44 years rainfall data have been analyze and its annual and season wise (Kharif, Rabi and Summer) probability of occurrence was predicted (Table 6). This predicts helps to optimize choice of crops, sowing date and irrigation scheduling for different crop cultivated in this region. The probability of occurrence of rainfall at 76 % confidence level is 534.2mm per annum, 395.9 mm in kharif season, 98.9 mm in rabi season and 39.4 mm in summer season.

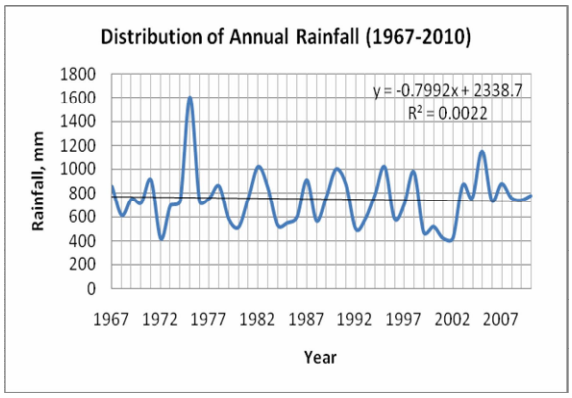

Fig.1. Distribution of Annual Rainfall (1967-2010) in southern Telanagana

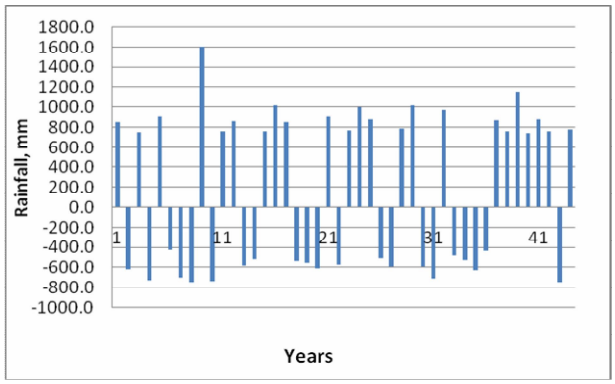

Fig.2.Annual Variability of rainfall over normal in southern Telangana

Table.1. Decadal shift in rainfall pattern at southern Telangana

Month/Year	1967-76	1977-86	1987-96	1997-06	2007-10
Jan	2.4	5.66	5.5	10.36	0
Feb	12.42	5.3	5.85	2.81	20.75
Mar	14.16	15.37	8.22	18.3	29.15
Apr	19.05	27.16	22.43	32.67	5.4
May	43.68	45.81	51.24	27.93	54.85
Jun	98.86	98.28	111.77	81.08	156.85
Jul	121.87	122.87	150.38	134.4	77.85
Aug	111.57	141.43	107.44	126.58	184.95
Sep	210.66	131.27	103.79	154.44	129.05
Oct	133.52	70.12	130.77	122.4	76.45
Nov	35.64	34.37	58.41	10.87	50.85
Dec	2.16	7.04	7.08	5.07	6
Annual	**805.99**	**704.68**	**762.88**	**726.91**	**792.15**

Table.2 Annual Drought .analysis of Southern Telagana Region of A.P

Year	Rainfall (mm)	Category	Year	Rainfall (mm)	Category	Year	Rainfall (mm)	Category
1967	858.6	Normal	1982	1022.5	Normal	1997	710.1	Normal
1968	616.1	Normal	1983	850.5	Normal	1998	977.7	Normal
1969	753.7	Normal	1984	534.2	Mild drought	1999	476.3	Mild drought
1670	720.8	Normal	1985	553.5	Mild drought	2000	523.6	Mild drought
1971	911.7	Normal	1986	602.3	Normal	2001	625.2	Normal
1972	423.5	Normal	1987	911.9	Normal	2002	426.6	Mild drought
1973	699	Normal	1988	570.1	Normal	2003	869	Normal
1974	738.4	Normal	1989	769.5	Normal	2004	764.5	Normal
1975	1606.2	Normal	1990	1001.9	Normal	2005	1154.6	Normal
1976	731.9	Normal	1991	883.2	Normal	2006	741.5	Normal
1977	761.2	Normal	1992	507.4	Mild drought	2007	880.8	Normal
1978	861.8	Normal	1993	584	Normal	2008	763.8	Normal
1979	580.9	Normal	1994	790.5	Normal	2009	743.2	Normal
1980	517.9	Mild drought	1995	1019.7	Normal	2010	780.8	Normal
1981	762	Normal	1996	590.6	Normal			

Table.3 Seasonal rainfall rain fall variability at Southern Telangana

Sl. No	Season	Average Rainfall	Percent	SD	CV
1	Kharif	505.95	67.11	150.26	29.70
2	Rabi	165.77	21.99	108.52	65.46
3	Summer	82.22	10.91	40.42	49.15
	Annual	753.94	100	216.09	28.66

Table.4 Monthly average and extreme rainfall features (1967-2010)

Month	Mean	SD	CV, %	Month wise		
				Lowest	Highest	Year
January	5.44	12.91432	237.3956	0	53.2	1997
February	7.88	18.13054	230.083	0	80.6	2008
March	15.39	20.47264	133.0256	0	94.8	2008
April	23.52	23.51863	99.99418	0	86.5	1967
May	43.32	35.70505	82.42163	0	133.4	1990
June	102.89	64.12913	62.32785	9*	296.8**	1993* 2007**
July	127.42	76.8313	60.29768	13.2*	369.2**	2001* 1989**
August	127.5	78.56836	61.62224	0	305	1997
September	148.13	105.9457	71.52211	0	554	1975
October	110.77	96.20681	86.85277	1.3*	402.4**	1988* 1975**
November	36.28	52.94924	145.9461	0	298.4	1987
December	5.40	12.00073	222.2357	0	47.2	1986
Annual	753.94	216.0935	28.6619	423.5	1606.2	1972* 1975**

** Maximum Value * Minimum Value

Table.5 Weekly, minimum, maximum and mean rainfall with SD and CV

Weeks	Mean	SD	CV, %	Month wise		
				Lowest	Highest	Year
1	0.12	0.561	467.5	0	3.2	1985
2	1.22	4.094	335.57	0	20	1987
3	2.49	10.316	414.30	0	53.2	1997
4	1.47	5.528	376.05	0	25	1995
5	0.75	3.879	517.2	0	24.4	2004
6	2.22	6.707	302.12	0	30.8	1994
7	3.27	13.469	411.90	0	78	2008

8	1.80	8.157	453.17	0	50.2	1968
9	1.02	2.90	284.31	0	13.4	2006
10	3.26	9.220	282.82	0	40	2005
11	2.85	7.340	257.54	0	32.3	2003
12	3.74	11.970	320.05	0	46.9	2008
13	5.17	10.382	200.81	0	48.2	2008
14	4.38	10.685	243.95	0	58.3	1977
15	5.07	12.527	247.08	0	74.1	1976
16	7.66	13.926	181.80	0	59	2006
17	5.49	12.168	221.64	0	56	2004
18	7.64	12.303	161.03	0	75.2	1967
19	8.13	15.3	188.19	0	64.4	1992
20	9.35	13.379	143.09	0	60.8	1979
21	10.81	15.263	141.19	0	61.2	1990
22	15.17	21.068	138.88	0	87.8	1971
23	15.08	19.029	126.19	0	87.9	1989
24	35.78	41.283	115.38	0	156.8	2007
25	20.37	21.084	103.51	0	71.8	2007
26	25.65	27.150	105.85	0	91.6	1973
27	23.71	24.858	104.84	0	96.4	2010
28	24.79	29.546	119.19	0	147	2005
29	34.49	38.895	112.77	0	175.6	1989
30	34.63	38.892	112.31	0	174.9	1989
31	27.40	30.489	111.27	0	117.4	1981
32	33.91	42.178	124.38	0	158.9	1987
33	32.47	42.934	132.23	0	182.1	1978
34	25.43	30.122	118.45	0	98.8	2009
35	19.81	28.998	146.38	0	125	1975
36	32.13	46.899	145.97	0	226	1975
37	23.30	30.861	132.45	0	131.7	1982
38	38.50	48.346	125.57	0	276.1	1991
39	40.99	58.899	143.69	0	279.5	1975
40	33.68	40.288	119.62	0	176.8	1994
41	27.86	33.558	120.45	0	111.4	1975
42	20.56	31.432	152.88	0	112.5	1982
43	18.683	30.957	165.70	0	115.8	1990
44	19.60	39.178	199.89	0	220	2005
45	10.09	18.070	179.09	0	68.8	1982
46	11.72	32.772	279.62	0	177.9	1987
47	4.44	9.564	215.41	0	39.8	1990
48	3.70	11.229	303.49	0	45	2008
49	2.69	9.497	353.05	0	44.8	1993
50	1.11	4.541	409.10	0	26	1988
51	0.18	0.899	499.44	0	5.6	1969
52	0.97	6.312	650.72	0	41.4	1986

Table: 6 Probability of occurrence of seasonal and annual rainfall

Rank	T	P	Rainfall, mm			
			Kharif	Rabi	Summer	Annual
1	45	2	989.8	501.6	114.8	1606.2
2	23	4	731.6	192.5	53.6	977.7
3	15	7	716	68.6	96.2	880.8
4	11	9	710.9	15.8	42.8	769.5
5	9	11	698.3	19.3	141	858.6
6	8	13	683.6	383	88	1154.6
7	6	16	676.1	131	76.1	883.2
8	6	18	663.6	115.7	82.5	861.8
9	5	20	651.9	163.9	53.2	869
10	5	22	621.9	236.1	164.5	1022.5
11	4	24	621.7	187	41.8	850.5
12	4	27	612.8	197.4	101.5	911.7
13	3	29	578.9	289.6	151.2	1019.7
14	3	31	555.4	50.8	155.8	762
15	3	33	550.8	153.6	76.4	780.8
16	3	36	549.8	306.8	145.3	1001.9
17	3	38	536	127.8	97.4	761.2
18	3	40	529.8	169.4	54.5	753.7
19	2	42	525.8	90.2	104.8	720.8
20	2	44	515	83.8	142.7	741.5
21	2	47	496.2	203	44	743.2
22	2	49	490.3	80.4	54.5	625.2
23	2	51	485.5	51.6	33	570.1
24	2	53	481.7	205.5	11.8	699
25	2	56	459.9	19.1	44.6	523.6
26	2	58	453.7	425.6	32.6	911.9
27	2	60	447.2	134.2	34.7	616.1
28	2	62	445.2	224.3	68.9	738.4
29	2	64	439.1	180.2	90.8	710.1
30	2	67	431.8	191	141	763.8
31	1	69	423.7	205.3	102.9	731.9
32	1	71	413.6	22.5	81.8	517.9
33	1	73	399.6	103	50.9	553.5
34	1	76	395.9	98.9	39.4	534.2
35	1	78	381.5	266.4	116.6	764.5
36	1	80	377.7	179.1	45.5	602.3
37	1	82	370.8	35.8	69.7	476.3
38	1	84	353.1	104	123.8	580.9
39	1	87	349.2	155.2	79.6	584
40	1	89	341.3	218.2	31.1	590.6
41	1	91	338.5	342.7	109.3	790.5
42	1	93	275.3	114.2	34	423.5
43	1	96	249.9	139.6	117.9	507.4
44	1	98	241.3	110	75.3	426.6

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RESEARCH ARTICLE

Comparative Study of Treatment of Sugar-Mill Wastewater Using Upflow Anaerobic Sludge Blanket Reactor & Hybrid Upflow Anaerobic Sludge Blanket Reactor

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ABSTRACT

Sugar industry is one of the major agro based industries in India, of which the state of Karnataka stands in the third position. Treatment and safe disposal of sugar mill wastewater has been cause of concern for many decades because of its high pollution potential. High rate anaerobic treatment has gained importance in better treatment of sugar mill wastewater. An attempt is made in the present study to treat the sugar-mill wastewater using Upflow Anaerobic Sludge Blanket (UASB) reactor & Hybrid Upflow Anaerobic Sludge Blanket (HUASB) reactor and observe its response for varying feed chemical oxygen demand (COD) and Hydraulic retention time (HRT). The laboratory-scale UASB & HUASB reactors were fabricated from acrylic pipe with an effective volume of 7.6 L and polypropylene rings as a packing media were used only in HUASB reactor and the reactors were operated for 200 days in two phases, first phase was operated by varying feed COD concentration, with a constant HRT, COD removal efficiency of about 95% for UASB and 96% for HUASB were achieved. VFA level was fluctuating between 1080-182mg/L.While the second phase was operated by varying HRT with constant feed COD concentration. COD removal efficiency of about 96%, UASB reactor produced biogas around 30L/D with methane content up to 65%, while HUASB reactor produced biogas around 31 L/D with 85% of methane content in it. OLR of 24kgCOD/m^3day was found to be the best as the highest Normalized Methane Production (NMP) of 0.18 m^3CH_4/KgCOD was achieved only for that OLR. Reactor responded very well for both the phases.

Keywords: HUASB, HRT, Biogas, Methane, Volatile fatty acids, COD, BOD, NMP.

INTRODUCTION

Sugar industry is one of the major agro based industries in India, comprising around 571 industries in the country (economy watch, report) of which the state of Karnataka stands in the third position comprising around 51 industries (India Business Directory, 2007). Sugarcane is one of the major commercial crops grown here in north part of Karnataka & is one of the major sources of revenue for majority of the farmers here, since sugarcane production is abundance in this region we find most of the sugar industries situated near the agricultural fields, these industries produce huge volumes of wastewaters containing high organic matter; also this region frequently faces the water problem hence it is of great importance to maintain the quality of natural water sources. If the sugar wastewater is let into the natural streams without any treatment, there is sure the risk of oxygen depletion in the receiving water; hence there is typically some form of treatment required for the sugar wastewater before its disposal into the natural streams. Hence agricultural use of such treated wastewater will solve both the problems of water supply for irrigation as well as disposal of wastewater in this region.

Till the late 1960s, aerobic processes were very popular for biological treatment of waste. The energy crisis in the early 1970s, coupled with increasingly stringent pollution control regulations, brought about a significant change in the methodology of waste treatment (Arun Kansal *et.al*, 1998). Energy conservation in industrial processes became a major concern and anaerobic processes rapidly emerged as an acceptable alternative. This led to the development of a range of reactor designs suitable for the treatment of low, medium, and high strength wastewater (Arun Kansal *et.al*, 1998). An increasing realization of the potential of anaerobic treatment is evident from the large number of recent research publications on this process. High rate anaerobic treatment has gained importance in better treatment of sugar mill wastewater because apart from treating the wastewater, energy can be recovered in the form of methane produced from the anaerobic system.

Effective use of methane from waste can be a substitute of oil and coal which thus result in saving the nonrenewable energy sources by reducing the use of fossil fuels (Arun Kansal *et.al*.1998). Advances in anaerobic treatment of domestic wastewater offer a few promising options including Anaerobic Filter (AF), Anaerobic Baffled Reactor (ABR), Hybrid reactor (HR), Anaerobic Migrating blanket Reactor (AMBR), Up flow Anaerobic Sludge Blanket (UASB) and Expanded Granular Sludge Bed (EGSB). It is reported that most of the negative aspects of high rate anaerobic reactors can be overcome by restricting the supported material to the top 25 to 30% of the reactor volume (Banu et.al, 2006). This reactor is named in different ways in the literature namely upflow sludge bed filter (UBF), sludge blanket anaerobic filter (SBAF) hybrid up flow anaerobic sludge blanket reactor (HUASB) reactor or simply a hybrid reactor. The negative aspects in full scale anaerobic filter (AF)such as dead zone, short circuiting and lower specific activity of biomass (at the bottom)can be over come by reducing the support material to a layer over a sludge bed from 10to 50% of the reactor volume . It works on the combined principle of UASB and AF advantage of this kind of reactor is, it retains high amount of biomass inside the reactor and even without granular sludge, it is to develop granular biomass (J. Rajesh Banu et.al, 2007).

The hybrid UASB reactor is an improved version of the UASB system & combines the merits of the up flow sludge blanket and fixed films reactors. This reactor offers strong resistance to disturbance such as large fluctuations in loading rates and HRT's. As most of the microbes adhere firmly to the support media, any change in fermentation conditions would only temporarily affect the microbes.

HUASB's have been used to treat wastewaters containing long chain fatty acids (Ching-Shyung et.al,1997), wastes from pharmaceutical units (Hentry et.al, 1996), distilleries (Shivayogimath et.al, 1999), (Mirandal et.al, 2005),(R.Farina et.al), dairy wastewaters (Banu et.al, 2007) sago wastewaters(Banu et.al, 2006), Tannery wastewaters (J.Rajesh Banu et.al, 2007), Slaughter house waste waters(Mirandal et.al, 2005), and domestic sectors (Banu et.al, 2007), (Elmitwalli et.al, 2002). This study shows a big potential for abetment of fossil fuels like coal and oil through methane capture from Sugar industry wastewater using HUASB reactor. An attempt is made here to treat the sugar-

mill wastewater using HUASB reactor and also to observe the response of the reactor for the varying HRT and feed COD concentrations.

MATERIALS AND METHODS

The laboratory-scale UASB & HUASB reactors were fabricated from 5mm thick acrylic pipe with external diameter of 100 mm and overall height of 1.3 m. A schematic diagram of the experimental setup is shown in Figure1. The total volume of the empty reactor was 8.2 L with provision of gas headspace of about 0.05m above the effluent flow line. Along the height of the reactor five sampling ports were provided at an interval of 0.18m. Miclins peristaltic pump of Model PP30 was used to feed the reactor. The reactor was packed with 239 numbers Polypropylene Pall rings; each ring had a volume of 0.8×10^{-6} m^3, which filled the 25% of reactor volume. The packing zone represents liquid column separated the screen and effluent over flow line. The gas outlet was connected to a wet gas flow meter through rubber tubing which actually recorded the total biogas production, effluent pipe was bent in the U shape to make a water seal and avoid the escape of gas. The outlet of the first wet gas flow meter was then connected to another wet gas flow meter through a series of connections passing through a sealed conical flask containing 0.1N NaOH then to a column containing pallets of lime and soda ash, which thus recorded the methane production (Ching-Shyung et.al,1997) . Provision for sludge withdrawal was provided at the bottom of the reactor with 0.02 m size tube. The lid of the bioreactor and other fittings were sealed to maintain strict anaerobic conditions inside the reactor. The reactor was supported by framed structure made up of mild steel.

Packing media

Cylindrical Polypropylene pall rings are used as the packing media, the volume of each ring worked out to be 0.8×10^{-6} m^3. The reactor was fed with 239 polypropylene rings, which were 25% of the reactor volume and occupied 0.3m of the reactor hight; a screen was fit just below the gas chamber of the reactor to hold the pall rings in the top portion. The void volume in these media ranges from 85-95 %. Moreover, these media provide high specific surface area typically $100 m^2/m^3$ or above which enhance bio film growth. The rings used for the present study are shown in fig 2.

Substrate

Sugar industry wastewater was used for the study, which was obtained from Badagandi sugar factory. This wastewater was analyzed for various parameters like pH, total solids, total suspended solids, volatile fatty acids, total kjeldal nitrogen, phosphate, chemical oxygen demand (COD) and Biochemical oxygen demand (BOD). The analysis of all the above parameters was done as per standard methods. The characteristics of the wastewater are given in Table 1.

Table 1: Characteristics of sugar wastewater used in the study

Parameters	Range
pH	5.2-8.28
Color	Reddish Yellow
Total suspended solids, mg/l	760-800
Volatile fatty acids, mg/l	173-2190
Total Kjeldal nitrogen(TKN) , mg/l	15-40
Phosphate, mg/l	6-10
Chemical oxygen demand(COD) , mg/l	1000-4340
Biochemical oxygen demand(BOD), mg/l	350-2750

Inoculum

The reactor was inoculated with 1.7 liters of active anaerobic sludge obtained from septic tank; the characteristics of the seed sludge charged into the reactor are given in Table 2.

Table 2: Characteristics of sludge used in the study

Parameters	Values
pH	7.6 ± 0.4
Total suspended solids g/l	32.4
Volatile suspended solids g/l	19.40
Color	Dark grey
Volume of sludge, liters	1.7
Depth of sludge bed m	0.28

Chemicals

Various chemicals required for the present study are classified into three groups namely micronutrients, macronutrients and secondary chemicals. The inorganic micro and macronutrients used in this experiment are as listed in Table 3. (All chemicals were of analytical grade). Analytical grade chemicals were used for the preparation of standard solutions and indicators.

Table 3: Micro and macro nutrients in the study

Chemical	Dosage (mg/L)
$FeCl_3$	4.83
NH4Cl	280
K2HPO4.3H2O	330
$MgSO_4.7H_2O$	100
$CaCl_2.2H_2O$	10
H_3BO_3	0.050
$ZnCl_2.2H_2O$	0.5
$CuCl_2.2H_2O$	0.038
(NH4)6Mo7O24.4H2O	0.050
$AlCl_3.6H_2O$	0.090
$NiCl_2.6H_2O$	0.142
$Na_2SeO_3.5H_2O$	0.164
$CoCl_2.6H_2O$	2
36% HCl	0.001 $ml.l^{-1}$
EDTA	1

Rector operation

The reactor was operated in two phases

i) Maintaining constant HRT and varying feed COD concentration.

ii) Maintaining feed COD concentration and varying HRT

Concentration in the first phase and HRT in the second phase were varied based upon the steady state conditions attained by the reactor (A.K.Ragen et.al, 2007) Table.4 gives the details of the reactor operations carried out during the study. Influent and effluent samples were collected once in two days and were tested for COD, COD removal efficiency was calculated. The reactor was closely monitored for pH, COD, biogas production, methane content Alkalinity and VFA.

Table 4: Reactor operation pattern during the study

Phase	Days	Feed conc. (mg COD/l) ± 50mg/l	HRT (Hrs)	OLR (Kg COD/m³ D)
I	1 to 33	1000	48	0.5
	34 to 54	2000	48	1.0
	55 to 75	3000	48	1.5
	76 to 96	4000	48	2.0
II	97 to 114	4000	36	2.67
	115 to 132	4000	24	4.0
	133 to 147	4000	18	5.3
	148 to 162	4000	12	8.0
	163 to 177	4000	6	16.0
	178 to 189	4000	5	19.2
	190to200	4000	4	24.0

Frequency of sampling

The samples were collected daily from all the ports provided all through the length of the reactor, such collected samples were analyzed immediately for pH, Alkalinity, TSS. VFA (influent and effluent), biogas production and methane content were observed every day and COD were analyzed after every second day. Influent and effluent BOD was analyzed once in a week. Reactor operation was not altered till the reactor reached the steady state condition (A.K.Ragen et.al, 2007)

Methods of analysis

Methods for the various parameters like biogas production and its methane content, pH, alkalinity; Volatile Fatty Acids (VFA), Chemical Oxygen Demand (COD), Volatile Suspended Solids (VSS), Total Kjeldal Nitrogen (TKN), etc were analyzed as per Standard Methods 2000.

RESULTS AND DISCUSSION

The reactor was operated in two phases. First phase was operated by increasing the feed COD concentration with a constant HRT; the feed COD concentration was gradually increased from 1000-4000mg/L, based upon the steady state condition achieved by the reactor (A.K.Ragen et.al, 2007). The increments of 1000mg/L in feed COD concentration was made with an intention to provide sufficient food for the biomass, since the temperature was in a mesophilic condition during the study it boosted the biomass in digesting the provided food. OLR was increased from 0.5 to 2 KgCOD/m^3.day After having reached the value of 4000mg/L the feed concentration was no more increased because the source wastewater COD itself was 4340mg/L After having reached feed COD concentration of 4000mg/L the first phase of reactor operation was then terminated . Fig 1 shows the variation of feed COD concentration during the study.

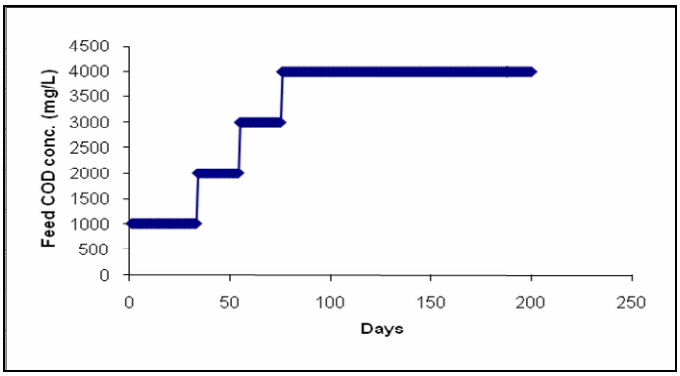

Fig 1: Variation of feed COD concentration during the study

Second phase of the study was carried out to observe the response of the reactor for the reducing HRTs, the gradual reduction in the HRT from 48hrs to 4hrs was made. The HRTs were reduced again based upon the steady state condition achieved by the reactor (A.K.Ragen et.al, 2007). During the second phase HRT was reduced by 25% for the first three attempts and for 50% for the fourth attempt and by 16-20% for the last two attempts. Such a random reductions in HRTs were made in order to study the response of the reactor for the gradual and sudden fall off of the HRTs. OLR was increased from 2.67 to 24 KgCOD/m^3.day. Fig 2 Variation of HRT during the study.

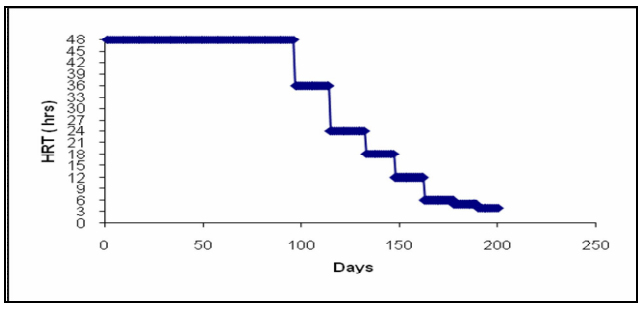

Fig 2: Variation of HRT during the study

Based upon the steady state condition achieved by the reactor OLR was varied from 0.5to 2 KgCOD/m^3.day in the first phase and from 2.67 to 24 KgCOD/m^3.day in the second phase. OLR increment was made again based upon the consistency of the reactor. Fig 3 shows the Variation of OLR during the study.

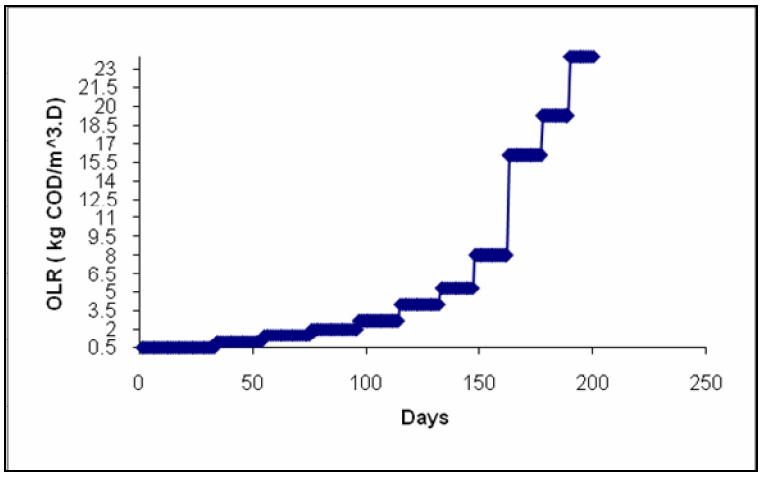

Fig 3: Variation of OLR during the study

COD removal efficiencies gradually increased for a particular feed COD concentration. a sudden fall in the COD removal efficiency for the next higher feed was seen, this was because of the acclimatization time required for the biomass. However after a period of 80 days COD removal efficiency was maintained at a fairly constant which thus proved the acclimatization the sludge.

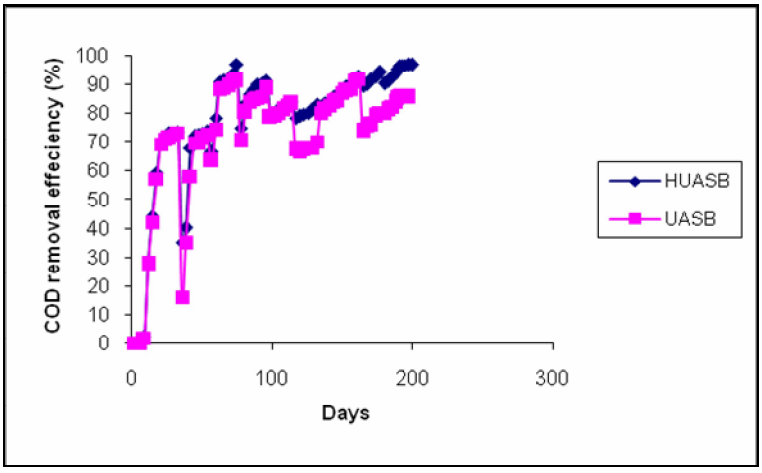

Fig 4: Observed COD removal efeciency during the study

No biogas production was observed for the first eleven days, it was because of the fact that the septic tank sludge used as the source of biomass took the time for acclimatization. When the sludge acclimatized it started producing the biogas. It was on the twelfth day a slight biogas of 0.05L/day was observed; henceforth the increment in the biogas production was gradually observed which went up to 8L/day for the fed OLR of 0.5 to 19.2 kg COD/m^3.day. It was for the OLR of 24 kg COD/m^3 .day intermittent feeding (Nidal, 2002) for the reactor was done as a trial i.e. reactor was not fed during the night eight hours , stunning performance in the bio gas was observed which went up to as high as 30L/day. Fig 5 Biogas production for the fed OLR.

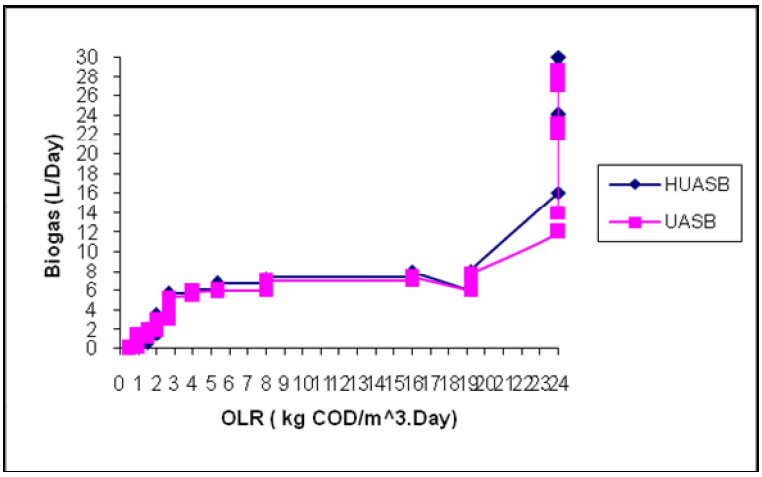

Fig 5: Observed biogas production for the fed OLR

For the first few days since the biogas production though the methane production was observed it was so less that hardly it could be measured. This trend continued for few more days till the biogas around 6L/day was produced i.e. up to an OLR of 2.67 kg COD/m^3.day, later on it was for the OLR of 4 kg COD/m^3.day around 40% of the methane gas was found of the total biogas produced, methane content in the biogas gradually increased to 65% in the next few days i.e. up to the OLR of 5 kg COD/m^3.day. Stunning methane content of 87% was observed at an OLR of 24 kg COD/m^3.day whose content slightly fell down to 85%. In this OLR methane content fell in the range of 80 to 85%.Normalised Methane Production of 0.18 m^3CH_4/Kg COD was achieved only at this OLR. Fig 6 shows the Production of Biogas and the methane content.

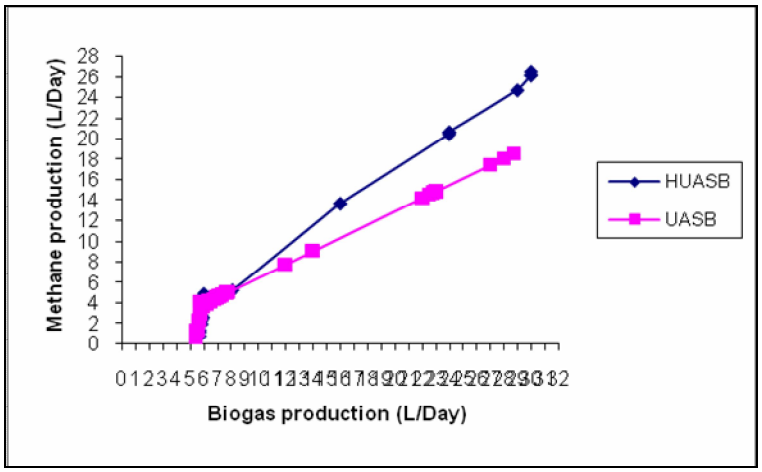

Fig 6: Biogas Vs Methane production observed during the study

Effluent pH was observed in the range of 8.2-6.7 and in no case it was neither more than 8.2 nor less than 6.5 .Based upon the present study this pH range was an indicative of the probable best reactor environment. Fig 7 shows Effluent pH during the study.

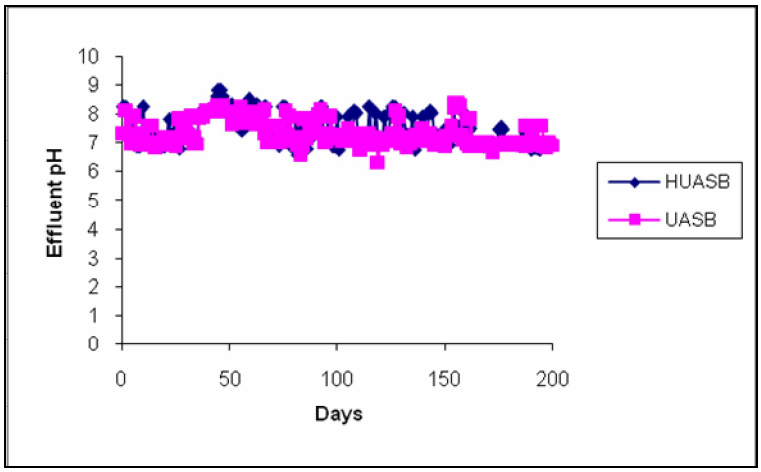

Fig 7: Variation of effluent pH observed during the study

BOD tests were conducted fort the effluent sample once in a week and effluent BOD to COD ratio was found and was in the range of 0.5 to 0.7.Fig 8 shows the variation of effluent BOD with respect to effluent COD concentration.

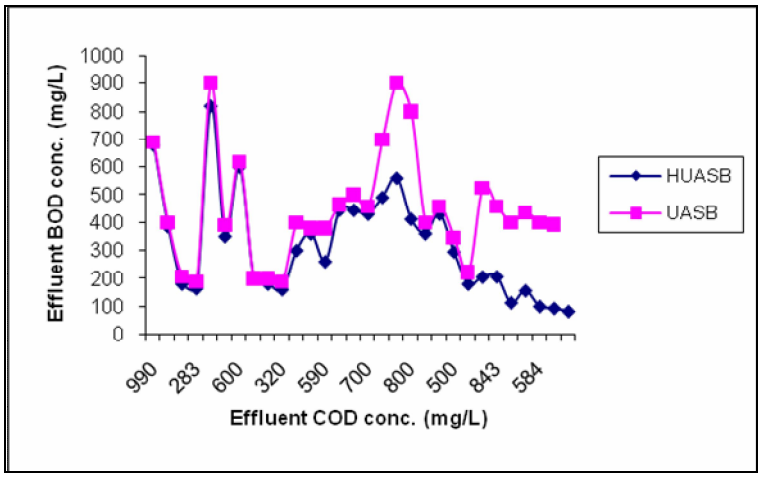

Fig 8: Variation of effluent COD with effluent BOD

The ratio of effluent VFA / COD was observed in the range of 0.7-0.8. This range provided additional information regarding the consistency of the reactor. Fig 9 shows the Variation of effluent VFA with effluent COD.

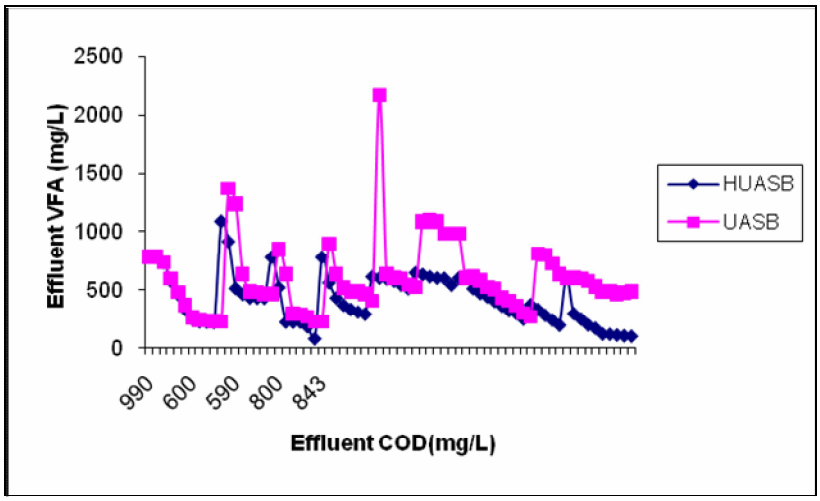

Fig 9: Variation of effluent VFA with effluent COD

Except at the initial stage i.e. before the acclimatization of the sludge no fluctuations were observed in the COD removal efficiency, which was fairly in between 85-90% even at varying feed COD concentrations and HRTs.

CONCLUSIONS

Experimental study carried out with the laboratory scale UASB and HUASB reactors to understand their feasibility for treating sugar industry wastewater, based upon the experimental results following conclusions were drawn.

1. Non granular anaerobic sludge can also be fed as a seed, also with suitable nutrient addition within a short period of 120 days granulation can be achieved.
2. Both the reactors responded very well for increasing feed COD concentrations as well for reducing HRT's.
3. Micro and macro nutrients fed during the reactor operation helped the granulation, increased efficiencies and biogas production
4. HRT of 4 hrs feed concentration of 4000 mg/L with OLR of 24 kgCOD/m^3D was found to be the best feed for both the reactors.
5. At OLR of 24 kgCOD/m^3D UASB reactor produced biogas around 30L/D with methane content up to 65%, while HUASB reactor produced biogas around 31 L/D with 85% of methane content in it.
6. Granulation minimized the problem of sludge washout, 0.05g/L for HUASB and 0.2 g/L for UASB
7. Polypropylene pall rings proved to be a best packing media.
8. Temperature in the range of 29-36^{o}C is best suited for the effective reactor operation
9. Maximum COD removal efficiency of 96% for HUASB reactor and 95% for UASB reactor can be achieved.
10. By treating the wastewater with HUASB or UASB energy in the form of Methane can be extracted.

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RESEARCH ARTICLE

Mass Transfer Coefficient Evaluation for Laboratory Scale Fermenter Using Sodium Sulphite Oxidation Method

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ABSTRACT

Oxygen transfer is often the rate-limiting step in the aerobic bioprocess due to the low solubility of oxygen inside the aqueous solution. (Cooper *et al*. 1944) describes the oxidation of sodium sulfite, with copper or cobalt ions as catalyst, which serves to keep a low level of oxygen in the liquid phase. The rate of reaction is such that as oxygen enters the liquid phase, it is immediately consumed to oxidize the sulfite so that the rate of oxidation is equivalent to the oxygen-transfer rate. Reaction rate often determined by titration is much faster than oxygen transfer rate so that gas- liquid mass transfer is the rate controlling step. The current study involves using central composite design, a statistical technique to find out the parameter conditions for the optimum volumetric mass transfer coefficient in a lab scale (2L) fermentor. The optimum volumetric mass transfer coefficient was found to lie outside the range of parameters studied and analytical expressions was obtained to predict the volumetric mass transfer coefficients for the parameter ranges studied using response surface methodology. The analytical expression was found to be significantly valid based on ANOVA results.

Keywords: Aerobic bioprocess, Sodium sulphite oxidation process, Mass transfer coefficient, OTR, Central composite design, ANOVA.

INTRODUCTION

In aerobic fermentation processes, oxygen is an important nutrient/substrate for the growth, maintenance and production of metabolites. But oxygen is sparingly soluble in aqueous and/or fermentation media due to its low solubility. Hence, oxygen needs to be supplied continuously during the fermentation. The oxygen transfer rate and oxygen uptake rate governs the design and scale-up of fermenters. (Felix Garcia-Ochoa 2009, Shukla, Kulkarni and Pandit, 2001). The oxygen transfer rate is limited by the volumetric mass transfer coefficient due to the mass transfer limitation of oxygen in the liquid film surrounding the gas bubbles based on gas-liquid film theory. Several theories have been proposed like (Felix Garcia–Ochoa, 2004) Whitman's two-film theory (1923), Higbie's penetration theory (1935) and Danckwert's surface renewal theory (1951) for prediction of mass transfer coefficient. However, parameters such as film thickness, exposure time and surface renewal rate proposed in the theories respectively cannot be measured experimentally but can be calculated if mass transfer coefficient value is known. Several methods are available to experimentally determine the volumetric mass transfer coefficient. Among the methods, the most widely used is the sulphite oxidation method. The sulphite oxidation method tends to give higher values for the volumetric mass transfer coefficient and the order of the reaction depends on the concentrations of the sulphite and catalyst. The aim of this study is to predict the volumetric mass transfer coefficient based on parameters both physical and chemical viz; impeller speed and air flow rate for sodium sulphite oxidation method. Central composite design is used to optimize the volumetric mass transfer coefficient for both impeller speed and air flow rate. The rate of dissolution of gas inside the liquid solution is studied by knowing the reaction kinetics and mass transfer theories.

MATERIALS AND METHODS

Copper sulphate, Sodium sulphite, Sodium thiosulphate, Iodine and Starch indicator, all analytical grade were obtained from Qualigens Fine Chemicals, Division of Glaxo-Smithkline Ltd., Mumbai.

Sodium sulphite oxidation method

(Cooper et al. 1994) first developed this method. This method is based on the reaction of sodium sulfite, a reducing agent, with the dissolved oxygen to produce sulfate, in the presence of a catalyst (usually a divalent cation of Cu^{++} or Co^{++}).

$$Na_2SO_3 + ½\ O_2 \rightarrow Na_2SO_4 \quad \ldots(1)$$

0.003 M of copper sulphate solution was prepared in 1 L of demineralized water which was then transferred to the fermentor vessel. Agitation was started immediately at the required rpm. To this was added 1 L of 0.05 M sodium sulphite. Simultaneously, air was pumped into the solution via a sparger continuously. The oxygen in the air was immediately consumed by the sulphite oxidation. Since the reaction rate is much faster than the oxygen transfer rate, so the limiting factor is the oxygen transfer rate (Nienow A.W and Lilly M.D. 1979) when the dissolved oxygen concentration reached 0% saturation, the remaining unreacted sodium sulphite reacted with oxygen until no more sodium sulphite was present in the solution. Air was pumped continuously till the oxygen concentration in the fermentor reached 100% saturation.

At regular intervals of time, a sample was withdrawn from the fermentor. The sample was mixed with an excess of iodine reagent. The sample was then titrated with standard sodium thiosulphate solution ($Na_2S_2O_3.5H_2O$) to a starch indicator end point.The rate of sodium sulfite consumption was determined and k_La calculated according to the following equation.

$$\frac{-dC_{Na2SO3}}{dt} = 2k_L aC^* \quad \ldots(2)$$

Where,

C* -equilibrium concentration in moles /liter

t- Time in minutes or seconds

C_{Na2S03} concentration of sodium sulphite in mol/liter

The order of the reaction for both i.e., oxygen consumption and sodium sulphite consumption are determined by plotting ln (C/Co) versus time for oxygen consumption and concentration of sodium sulphite versus time for sulphite consumption to obtain linear plots.

Experimental Design and Data Analysis: Central Composite Design (CCD)

In order to study the combined effect of design or mechanical parameters such as impeller speed, and process or chemical parameters such as air flow rate , a statistical approach namely response surface methodology has been used. The process conditions can be optimized using Response surface methodology. Response surface methodology is an empirical modelization technique devoted to the evaluation of the relationship of a set of controlled experimental factors and observed results. Basically this optimization process involves three major steps, performing the statistically designed experiments, estimating the coefficients in a mathematical model, and predicting the response and checking the adequacy of the model. The Central composite design is employed for the optimization of process conditions (Khuri and Cornell 1987).

According to the Central composite design, the total number of treatment combinations was $2^k + 2k + n_o$ where 'k' is the number of independent variables and n_o is the number of repetition of experiments at the center point. The total number of design points is thus $N=2^k + 2k + n_o$.

The significant variables like speed of impeller & air flow rate were chosen as the critical variables and designated as X_1 and X2 respectively. The low, middle, and high levels of each variable were designated as –, 0, and + respectively. -α and +α are the extreme levels in the range studied for each variable ,α describe a circular design geometry ,which reduce errors by locating the axial points at the lower and upper bound of the variable ranges, which gives direct , mutual, curvilinear interaction . Factorial point should range -1 and +1, axial point –1.414 and +1.414 are intermediate levels between the central and extreme levels of each variable, and 0 is the central level in the range studied for each variable. The experimental range for Speed of impeller & Air flow rate are chosen for this study (Obtained using Design Expert Software, Stat-Ease, U.S.A.) is given in Table 1.

Table 1- Experimental range and levels of impeller speed and air flow rate in Central composite design (CCD).

Parameter	**Level**				
	$-\alpha$	-1	0	+1	$+\alpha$
Speed of impeller	217.16	300	500	700	782.84
Air flow rate	4.76	6	9	12	13.24

A 2^2-factorial central-composite-experimental-design was employed and all in duplicate, leading to 13 sets of experiments, was used to optimize the mass transfer coefficient. Experimental plan employed for the optimization of impeller speed and air flow rate (Obtained using Design Expert Software, Version 7.1.6, Stat-Ease, U.S.A.)

For statistical calculations, the variable X_i were coded as x_i according to the following transformation

$$x_i = (X_i - X_o) / \delta X \quad \ldots(3)$$

Where,

x_i = dimensionless coded value of an independent variable X_i,

X_i = actual value of an independent variable,

X_o = actual value of an independent variable X_i at the center point, and

δX = step change

The variables are preferably used in coded form for two reasons:

1. Computational ease and increased accuracy in estimating the model coefficients.
2. Enhanced interpretation of the coefficient estimates in the model.

The specific codes are:

Coded value of the impeller speed, $x_1 = [X_1 - 500] / 300$.

Coded value of the air flow rate, $x_2 = [X_2 - 9] / 6$.

Where $X_1$and X_2 are the actual values of the independent variables respectively.

Where x_1 and x_2 are the coded values of the independent variables viz., speed of impeller and air flow rate respectively. The values in the parenthesis are corresponding to decoded (actual) values.

The optimum mass transfer coefficient is taken as the dependent variable or response $\hat{Y}$. Regression analysis was performed on the data obtained. The behavior of the system can be explained by the following second order polynomial Eq. (4) (Khuri and Cornell 1987).

$$\hat{Y} = \beta_o + \Sigma\beta_i x_i + \Sigma\beta_{ii} x_i^2 + \Sigma\beta_{ij} x_i x_j \quad \ldots(4)$$

Where,

$\hat{Y}$ = predicted response (Volumetric mass transfer coefficient),

β_o = offset term,

β_i = linear effect,

β_{ii} = squared effect, and

β_{ij} = interaction effect.

x_i and x_j = coded value of independent variables.

The second order polynomial equation was obtained using Design-Expert software (Douglas and C Montgomery 1997 and Raymond and Douglas 1995).

RESULTS AND DISCUSSION

The volumetric mass transfer coefficient was determined using sodium sulphite oxidation method. The experiments were carried out in 2 L (working volume) fermenter.

The conventional practice of single factor optimization by keeping other involving factors at unspecified constant levels does not depict the combined effect of all the factors involved. Also this method requires carrying out a number of experiments to determine the optimum levels, which will not give true values. Optimizing all the affecting parameters combined by statistical experimental design can eliminate these drawbacks of single factor optimization process. The effect of the process conditions namely impeller speed and air flow rate were studied using a second order central composite experimental design (CCD) (Khuri and Cornell 1987).

A total of 13 experiments with different combinations of impeller speed and air flow rate were performed using central composite design to find the parameter conditions where the optimum volumetric mass transfer coefficient occurs.

Table: 2 show the comparison between experimental and predicted values for the volumetric mass transfer coefficient using sodium sulphite oxidation method. The error was well within $\pm$ 10 % indicating that the empirical expression for the prediction of volumetric coefficient is valid. The expression obtained in terms of coded factors is given by the equation

$$Y_1 = 607.58 - 23.99x_1 - 36.60x_2 - 15.08x_1x_2 + 27.66x_1^2 + 14.59x_2^2 \quad ...(5)$$

where Y_1 is the response variable i.e., volumetric mass transfer coefficient, x_1 and x_2 are coded values of independent variables, i.e., impeller speed and air flow rate respectively .

Actual form of the empirical expression gives the predicted value of volumetric mass transfer coefficient.

$$Y_1 = 749.257 - 0.5878X_1 - 4.3599X_2 - 0.02512X_1X_2 + 0.0006X_1^2 + 1.618\ X_2^2 \quad ...(6)$$

WhereY_1 is the response variable, Volumetric mass transfer coefficient. X_1 and X_2 actual values of independent variables, i.e., impeller speed and air flow rate respectively

Table 2 - Comparison of experimental and predicted values of volumetric mass transfer coefficient for 2 L sodium sulphite oxidation method

Run	Impeller speed (rpm)	Air flow rate (lpm)	Volumetric mass transfer coefficient $k_La(hr^{-1})$		(%)-Error
			Experimental	Model	
1	500.00	9.00	611.985	608.583	0.555
2	782.84	9.00	609.151	675.977	1.177
3	217.16	9.00	710.677	675.977	0.588
4	500.00	9.00	609.151	608.583	0.093
5	500.00	9.00	607.735	608.583	-0.139
6	500.00	9.00	604.151	608.583	0.608
7	300.00	12.00	727.204	721.619	-0.768
8	500.00	13.24	670.539	678.583	-1.257
9	700.00	12.00	672.900	670.774	0.315
10	500.00	4.76	596.402	575.691	3.472
11	700.00	6.00	609.151	626.961	-2.923
12	500.00	9.00	604.902	608.583	0.093
13	300.00	6.00	603.151	608.583	-2.497

The coefficient of determination, R^2= 0.9204, and the coefficient of correlation, R = 0.9593

The coefficient of determination, R^2= 0.9204, and the coefficient of correlation, R = 0.9593

The results of statistical testing using ANOVAs are given in Table 3

Table 3: Analysis of Variance (ANOVA) Table for the effect of speed of impeller, air flow rate on volumetric mass transfer coefficient.

Source	Sum of squares	Degrees of freedom	Mean square	F value	*Probability(P)>F
Model	24505.94	5	4901.19	28.74	0.0009 significant
Error	1193.78	7	170.54		
Total	25699.73	12			

F value $F_{0.0009\ (.5,7)}$ = 9.52 obtained from the standard distribution table.

* Values of " Probability (P) > F"less than 0.05 indicate that the model terms are significant.

The ANOVA of the regression model corresponding to quadratic Eq.(4) for volumetric mass transfer coefficient Table 3 demonstrates that the model is highly significant, as it is evident from the calculated F-value (= 28.74) and a very low probability value (Probability(P) > F = 0.0009). Moreover the computed F-value (F= 28.74) is much greater than the F value ($F_{0.0009\ (5,\ 7)}$ = 9.52) obtained from the standard distribution table (Khuri and Cornell 1987) so the null hypothesis is rejected at 5% α level of significance.

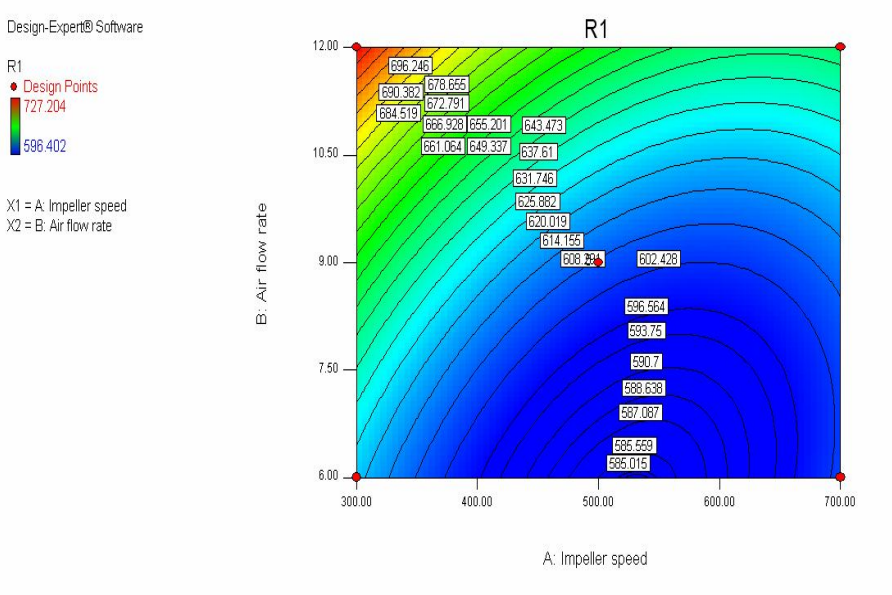

Fig 1 - Isoresponse contour plots showing the effect of impeller speed and air flow rate and their interactive effect on the volumetric mass transfer coefficient for 2 L sodium sulphite oxidation method.

From Fig. 1 it can be observed that a stationary point exists although it is outside the range based on the shape of the contour plot. The response surface plot shown in Fig. 2 for the chosen model Eq. (5) illustrates the three dimensional relationship for the effects of impeller speed and air flow rate on volumetric mass transfer coefficient. The response surface indicates that the volumetric mass transfer coefficient increases with decrease in impeller speed and subsequent increase in air flow rate. This result indicates that two variables had mutually dependent influence on the volumetric mass transfer coefficient.

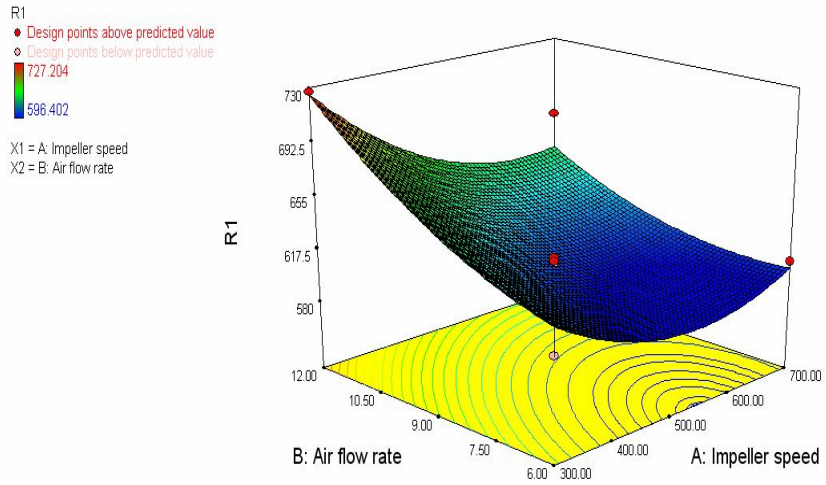

Fig 2 - Response surface plot showing the effect of impeller speed and air flow rate and their interactive effect on the volumetric mass transfer coefficient for 2 L sodium sulphite oxidation method

CONCLUSION

Evaluation of mass transfer coefficients in fermenters were studied using central composite design to get the optimum value. A total of 13 experiments for each set were employed to determine the volumetric mass transfer coefficients. The order of the reaction for oxygen consumption for 2 L sodium sulphite oxidation method was found to be first order and zero order for the case of sodium sulphite oxidation. Optimum volumetric mass transfer coefficient was found from response surface methodology to be outside the range of parameters studied. Analytical expressions for predicting the volumetric mass transfer coefficient for the range of impeller speed and air flow rate tested were obtained using response surface methodology.

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Congratulation

Congratulations to Young Investigator Award winner

Mr.Sirajuddin.M.Horaginamani

Mr.Sirajuddin M.Horaginamani receiving 2011 SAB Young Investigator Award recently in Mangalore from A.S.Sadashivaiah, Chairman, Karnataka State Pollution Control Board in the presence of Padamashree **a**wardee M. Mahadevappa, former Vice Chancellor, University of Agricultural Sciences, Dharwad.

Sirajuddin.M.Horaginamani, a research scholar in the Department of Environmental Management, Bharathidasan University, Tiruchirappalli, was honoured with the 2011 Young Investigator Award by the Society for Applied Biotechnology on the 22 - 23 July 2010 in Mangalore, in recognition of his creative scientific contribution in research and development of Environmental Management, at Mangalore recently.

A gold medalist with first Rank in his M.Sc. Environmental Sciences at Kuvempu University, Shivamogga, Karnataka, Sirajuddin has been pursuing his PhD under the research guidance of Dr.M.Ravichandran, Professor and Head, Department of Environmental Management, Bharathidasan University, Tiruchirappali, TamilNadu, India**.** He has published more than 19 research papers in national and international journals, and has participated in more than 75 conferences. He visited seven times abroad .To creates environmental awareness among school and college students across the country, he delivered many special talks and lead lectures.

On receiving this prestigious and much-deserved award!
We are enormously proud of you Sirajuddin for the great honour you got and for your outstanding achievements in the field of Environmental Management.
On behalf of IJONS and TNSRO we wish you for your continued success.

-Chief Editor and Team

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RESEARCH ARTICLE

Effects of Sugar Mill Effluent on the Primary Productivity of Hydrilla

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ABSTRACT

The effect of treated effluent of sugar mill industry on the primary productivity of *Hydrilla* was recorded. The primary productivity study was done by dark and light bottle method. The various concentrations of treated sugar mill effluent were taken to find out the effect of concentration of this effluent on the primary productivity of *Hydrilla*. It was found that the GPP and NPP values of *Hydrilla* plant decreases with increasing concentration of this effluent from 1% to 4%. The GPP values decreased from 46.9 mg O_2/g/day to 6.2 mg O_2/g/day at 4% similarly the NPP values decreased from 25.6mg O_2/g/day at 1%concentration to 3.36 mg O_2 4% concentration. Likewise the respiration decreased from 21.33 at 1% to and 2.90 mg O_2/g/day at 4% level. From these findings it is clear that even at low concentration of 4% of the treated effluent of sugar mill has profound inhibitory effect on primary productivity of aquatic ecosystems. The BOD, COD suspended solids of this effluent may interfere with the process of photosynthesis. Further, these findings recommended that the efficiency of treatment of process of the sugar mill has to be improved.

Keywords: Sugar mills, effluents, Hydrilla, GPP and NPP

INTRODUCTION

Water is the basis of life. Every living human, animal and plant contain a substantial proportion of free or combined water in it bodies and no kind of physiological activity is possible without this water. Thus water is one of the integral components of biosphere which plays a vital role in all forms life. *Hydrilla verticillata* is submerged fresh water plant which, as an invasive non native weed, often forms dense stands at the littoral region of ponds. *Hydrilla* is a herbaceous perennial submerged obligate (required a wet habitat) forming dense stands of very long stems in the water (WETZEL 1964). It reproduces mainly by the growth of stem fragments also by growth auxiliary buds and subterranean tubers. A single tuber can grow to produce more than 6000 new tubers per m^2 (Sutton et al., 1992).

Primary productivity

Productivity in the rate of production of organic matter accumulated in the producer component of an ecosystem in unit time and in unit area. According to (Odum 1971) primary productivity is defined as the rate at which radiant energy of sun in stored by photosynthetic and chemosynthetic activity of producers (Chiefly green plants) in the form of organic substances which can be used as food materials (0dum.1971). Globally primary productivity amounts to 243 billion metric tons of dry plant biomass year (Wetzel 1964). The total energy fixed by plants in a community through photosynthesis is referred to as Gross primary productivity (GPP). A proportion of the energy of gross primary productivity is used by plants in a process called respiration.
The general equation is

$$C_6H_{12}O_6+6O_2 \rightarrow 6CO_2+ \text{released energy}$$

Subtracting respiration from primary production gives us net primary productivity (NPP)
NPP represents the rate production of biomass available for consumption by heterotrophic organisms.

Environmental impacts of effluents from sugar mills

Waste water from sugar mills with its high BOD rapidly depletes available oxygen supply when discharged into water bodies endangering fish and other aquatic life. The high BOD also creates septic conditions, generating foul-smelling hydrogen sulfide, which in turn can precipitate iron and any dissolved salts, turning the water black and highly toxic for aquatic life. A high COD, a measure of the inorganic and partly organic non-biodegradable content of the effluents, has effects on the receiving water body similar to that of a high BOD. Suspended solids reduce light penetration and, as a result plant production in the receiving water body by increasing turbidity and can also clog fish gills. Benthic decomposition of components can decrease oxygen availability while anaerobic decomposition can produce hydrogen sulfide and release by products that increase BOD. Discharge of water with a high level of total dissolved solids would have adverse impact on aquatic life, render the receiving water unfit for drinking and also reduce the crop yields if used for irrigation and exacerbate corrosion in water systems and pipe.

MATERIALS AND METHODS

In the present work, to study the effect of industrial effluent on primary productivity, an aquatic submerged plant, *Hydrilla* was chosen. The *Hydrilla* plant was collected from the stagnant water of kudamurutti Channel of Cauvery

basin and also from (Lentic water region) of Uyakondan Channel. The collected *Hydrilla* plant was brought to the laboratory and kept in aquarium tank of size 60x30x15 cm which holds 150litres of water. At the bottom of the tank the river sand is places in order to provide anchorage for the growth of the *Hydrilla* plant. The water in aquarium tank was replaced once a week.

Collection of industrial effluents

In order to assess the effect of industrial effluent on the photosynthetic metabolism of *Hydrilla* plants, effluent from the Ambika sugar mill was collected. The treated effluent of sugar mill industry was collected in a polythene container of 5L capacity and brought to the laboratory for the present investigation.*liter

Dilution of the effluent

The treated effluent of sugar mill was diluted with tap water to 1%,2%,3%,and4%, concentrations. Primary productivity of *Hydrilla* plant was carried out by light and dark bottle method (Vollenweider, 1969). For the light and dark bottles, 500 ml capacities of BOD bottles were taken. To darken the BOD bottles aluminum foil paper was wrapped over the BOD bottles. The *Hydrilla* plant and different concentrations of sugar mill effluent such as 1%,2%,3%,and 4% were taken in light and dark bottles, the tap water was taken as control sample. Then the light and dark bottles were exposed to sunlight for duration of three hours. After the experiment,the wet weight of *Hydrilla* plant was weighed is and electric monoplane balance. For the primary productivity study the Winkler's method was used to estimate the dissolve oxygen.

Respiration

To calculate the respiration, the dissolved oxygen content of dark bottle was subtracted from the dissolved oxygen content of initial bottle.

Respiration = DO of Initial bottle – DO of dark bottle

Net primary productivity (NPP)

To estimate the net productivity (NPP) the dissolved oxygen content of initial bottle was subtracted from the dissolved oxygen content of light bottle.

NPP= DO light bottle – Do of Initial bottle

Gross Primary Productivity (GPP)

To find out the Gross primary productivity, the net primary productivity and respiration values were added

GPP = NPP + Respiration

The GPP, NPP and respiration values measured for three hours were then converted to twelve hours photo period. The GPP, NPP and respiration values are expressed in mg O_2/gm/day by dividing the wet weight of the *Hydrilla* plant. The dissolved oxygen content of the initial bottle was fixed by adding 2ml Manganous Sulphate and 2ml of alkaline Iodide. Similarly the dissolved oxygen in light and dark bottle was fixed after three hours exposure time. The precipitate was dissolved 2ml sulphuric acids. Then 50ml of the sample was taken in a conical flask and titrated against sodium thiosulphate of 0.01 Normality.

The dissolved oxygen was estimated by using by using the formula given below

$$\frac{0.01 \times 1000 \times 8 \times \text{volume of sodium thio sulphate volume of sample mg/l}}{\text{Volume of sample}}$$

RESULTS AND DISCUSSION

The values of Gross Primary Productivity (GPP), Net Primary Productivty and Respiration of Hydrilla_are given in the Table I and in Figure 1. From the Values it is clear that the gross primary productivity (GPP) of *Hydrilla* plant decreased when the concentration to treated sugar mill effluent increased from 1%to4%. The gross primary productivity (GPP) values decreased from 46.93 mg o2 /gm/day at 1% to 6.2 mg o2/gm/day at 4% concentration. Likewise the net primary productivity (NPP) values decreased from 25.6 mgo2/gm /day at 1%concentration of the effluent to 3.36 mg o2/gm/day at 4% concentration of diluted treated sugar mill effluent. Respiration also decreased as the concentration of the effluent increased. The rate of respiration at 1% was 21.33 mg O_2 /gm/day and the concentration increases to 4% the rate of respiration also decreased to 2.90 mg O_2/gm/day. As shown in the table I and figure 1, when the concentration increases from 1%, 2%, 3% ,to 4% , values of GPP,NPP and respiration decreased from the average value of control 45.86, 26.02, 19.84 mg O_2/gm/days respectively.

Primary productivity studies are essential for estimating the fish production potential of an impoundment and its scientific management the primary production of the producers is one of the most important sources of energy input in fresh water ecosystem (Golfman 1964). Studies on, primary productivity of fresh water bodies in India have been made to a limited extent.(Kannan and Job 1980). However studies on primary productivity of fresh water bodies regarding pollution aspects are wanting. In order to exploit the fresh water resources like pond and reservoirs for substantial fish culture and the primary production, these water bodies have to be assessed (Bolin et al 1977 and Brylinski and Mann1973). In this context an attempt has been made in the present investigation to know the effect of sugar mill effluent on the primary productivity of *Hydrilla.* These results of present investigation clearly shows that the primary productivity in terms of Gross primary productivity and Net primary productivity of *Hydrilla* plant is affected because of effluent of sugar mill industry, even though the effluent taken was treated, it has the inhibitory effect on the productivity of *Hydrilla* plant. The treated effluent may contain some amount of BOD, COD, suspended solids and mild amount of oil and grease which may affect the productivity of *Hydrilla* plant by prevent the light penetration and reduces the photosynthetic process.

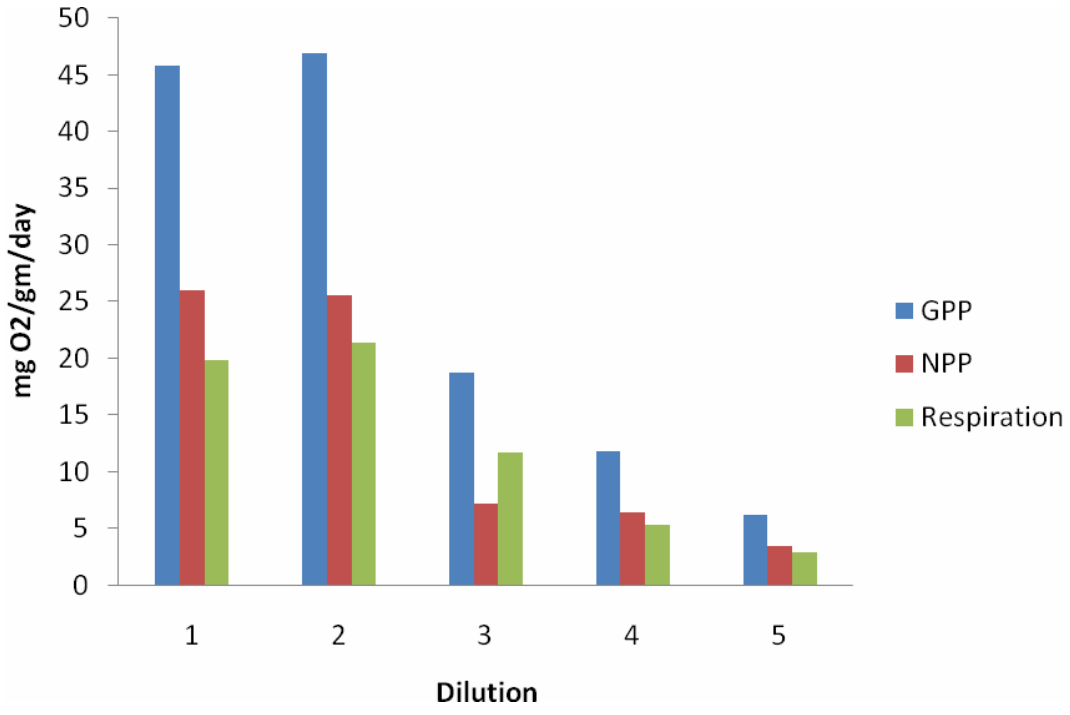
The same finding was also observed by Venkatraj (2000) also by Uthra (2002) and Damaries (2005) in Sago industrial effluent, Tannery effluent and Textile effluent respectively. The effect of sugar mill effluent in the presentt study has more profound effect than the effluent of sago, tannery and textile effluents. At 50% concentration of Glue industry, the values of GPP 8.4 mg O_2/ gm/ day NPP 2.4mg/O_2/gm/day were recorded by Venkatraj (2000). Similarly the effects of textile effluent on the productivity of *Hydrilla* have lower effects than the sugar mill effluent. The values of GPP 21.26 mg O_2/gm/day and NPP 10.88 mg O_2/gm/day for textile effluent were recorded at 10% concentration. Where as in the sugar mill effluent the GPP and NPP values of very low of 6.2 mgO_2/gm/day and 3.36 mg O_2 /gm/day respectively at 4% concentration. Hence the effect of sugar mill effluent has more profound effect than the glue and textile effluent even though the effluent of sugar mill was treated one. This finding leads to suggest to improve the efficiency of treatment processes of sugar mill waste.

CONCLUSION

The present investigation on the effect of sugar mill effluent on the productivity of *Hydrilla* shows that the GPP, NPP, Respiration values decreases in treated sugar mill effluent upto 4% concentration.(This may be due to the availability ?of nutrients for the growth of the plant. The NPP values are also decreased and this value to stress which may increase rate of respiration and reduce NPP the decreasing trend of GPP in treated effluent.) This may be due to the presence of suspended solids; BOD, COD and also its turbid nature prevent light penetration for photosynthesis. Higher respiration may due to some stress imported from dissolved solids present in the effluent on photosynthetic physiological mechanism and chlorophyll of *Hydrilla*.

Table I: Effects of sugar mill effluent on primary productivity of *Hydrilla verticillata*

Productivity (mg O_2 gm/day)	**Control**	**1%**	**2%**	**3%**	**4%**
GPP	45.86	46.93	18.74	11.73	6.2
NPP	26.02	25.6	7.11	6.4	3.36
Respiration	19.84	21.33	11.63	5.33	2.90



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RESEARCH ARTICLE

Integrated Solid Waste Management of Dharwad City -A Case Study

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ABSTRACT

The study throws light on the existing solid waste management practices in Dharwad city of Karnataka state. It include qualification of various waste components from different zones through field investigation covering collection mechanisms, generation rate, physical characteristics of the solid waste .At present solid waste is not segregated at the source and open dumping is carrying out which is not satisfying municipal solid waste rules 2000. For the qualitative analysis the sample of the solid waste was collected from the disposal site, analyzed and presented in this paper.

Keywords: solid waste management, collection mechanisms, qualitative analysis

INTRODUCTION

The purpose of solid waste management is to help, improve poor practices of solid waste management that prevail in many low income countries where this subjects has received scant attention compare to other aspects of other infrastructures, like water supply and transport. It is multi disciplinary field embarrassing waste collection transfer haulage, disposal and its impact is wide. It is therefore important to take a broad view. The two roots causes solid waste problems are urbanization and industrialization. Urbanization affects living habits and consequent waste characteristics. New products appeared abundance, which are considered to be cheaper to throw away. Recovery of materials has become more difficult. Solid waste has increased significantly in quantity and complexity with the advent of the throw away society and the growth of the packaged and processed food industry. The Dharwad city is

situated in Northern Karnataka with an altitude of 762m above MSL on latitude of 15°22'North latitude and 74°43' East longitude, with an area of about 1032sq.km. The climate of Dharwad is pleasant throughout the year being semi-malanad area. As per the statistical records of Dharwad city the population was around 2,91,085 lakhs during 2006.The average quantity of solid waste generated in Dharwad city is 515gms/capita/day.The daily disposal of waste is 150tones/day and the waste is mixed type, comprising of bio-degradable dry and inert in nature .This paper is an effort to present the segregated estimation of the different waste components to highlight its resources, recover and disposal recommendations.

MATERIALS AND METHODS

The study area has been divided into four zones covering totally 22 different wards for effective management of MSW. The study includes qualification various wastes from different zones through field investigation covering collection mechanisms, generation rate and physical characteristics of solid waste. The waste analyses have performed by taking 100kg of sample every time in different months from march, April, May, June, July and August. The waste is segregated for its organic and inorganic contents. The components chosen where food and vegetable waste, paper, plastic, textile, rubber, leather, wood, dust, ash and brick, glass and mixed waste. The organic content was oven dried and inorganic contents are sun dried to take dry weight .Six samples were taken from each zone every time .The chemical composition of the waste was also carried out for its various parameters.

RESULTS AND DISCUSSION

The physicochemical analysis of waste enables us to the quality of MSW. The results showed that the biodegradable fraction of MSW was high with an average value of 78%.

Table 1 - Shows dry mass of the waste released by Dharwad city during 2008

Table-1 Average dry mass of the Municipal solid waste in different zones of Dharwad city

Sl.No	Component	Zone-1	Zone-2	Zone-3	Zone-4
1	Food & Vegetable waste	13.76	13.71	13.42	13.6
2	Paper	10.21	10.29	9.76	11.39
3	Plastic	9.87	6.5	7.02	6.98
4	Textile	2.23	2.12	1.84	2.36
5	Rubber	1.84	1.82	1.48	1.88
6	Leather	1.52	1.5	1.25	1.66
7	Wood	1.71	2.28	2.08	2.27
8	Dust, ash, brick	7.62	9.9	10.6	9.82
9	Glass	1.59	1.58	1.42	1.22
10	Mix waste	15.58	12.7	14.84	11.96

Table 2- Percentage of the waste released by Dharwad city.

Sl.No	Component	Percentage
1	Food & vegetable waste	46%
2	Paper	11%
3	Plastic	8%
4	Textile	2%
5	rubber	2%
6	Leather	2%
7	Wood	2%
8	Dust, ash, brick	10%
9	Glass	2%
10	Mix waste	15%

Table 3 - Physical and Chemical characteristics of the waste.

Sl.No	Parameters	Results
1	Ec ds/m (1:2.5)	3.3
2	P^H (1:2.5)	8.2
3	Total Nitrogen	0.36%
4	Total Phosphorus	0.74%
5	Total Potassium	0.40%
6	Total organic carbon	2.88%
7	C/N Ratio	7.9/1

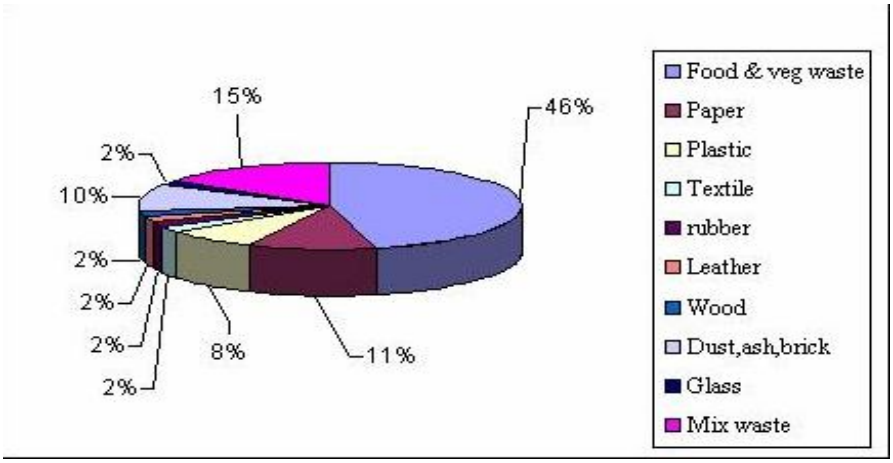

Figure 1 - Indicates the results of solid wastes in graphical method

CONCLUSION

From study it is concluded that MSW has higher percentage of biodegradable fraction as it is difficult to separate the dry waste from biodegradable ones, it is proposed to compost the mixed waste. The higher percentage of biodegradable fraction can also be utilised as an energy source by subjecting it to bio methanation process. Efforts can also be made to produce fuel pellets (small tablets) from Municipal solid waste .The Implementation of these recommendations would result in solving the municipal solid waste problems of Dharwad City.

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