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Design of Experimental Setup for Durability of Paddy Straw for Erosion control in Pune, India

[I]Dr. S. A. Halkude, [II]R. C. Katdare
[I]Principal, Walchand Institute of Technology, Solapur, Maharashtra State, India.
[II]Research Scholar, Walchand Institute of Technology, Solapur, Maharashtra State, India.

Abstract

The Paddy straw is a Lignocellulosic crop residue abundantly available in India, also referred as natural biodegradable polymeric material and although incorporated in small quantity in soil to retain nutrients but majority is often burnt in the open field to solve its disposal problem but leads to serious air pollution and therefore Reuse is now proposed by preparing manually a Geo-mesh out of the plaited ropes of Paddy which would be laid on outer slopes of newly constructed embankment of various civil Engineering structures to control the soil erosion. The durability of the said Geo-mesh is expected to last at least one year in which a new embankment is expected to acquire designed shear strength required for the stability of new slope. During this settling period the mesh would be able to support and stabilize the new embankment by natural process of consolidation / compaction and also help to establish good vegetation cover for controlling soil erosion, which is expected to maximum during initial season. Out of the several experimental methods available, the method of carrying out accelerated biodegradation of Paddy straw Geo-mesh, kept in different soil embedment, by treating Geomesh, chemically with NaOH, Urea, Superphosphate and Acids and biologically with fungi was adopted for calculating durability. The same in this case is expressed in days and is calculated in terms of reduction in tensile strength before and over a period of time of the experiment (every 15 days for 90 days) till the residual tensile strength of Geo-mesh reaches 0.10 kN/m (The minimum prescribed value of tensile strength of Geomesh for Erosion Control is 0.073 kN/m as per the guidelines of Erosion Control Technology Council (ECTC), USA for temporary type OWT having typical twelve months longevity). The tensile strength of Geomesh is found on Textile testing machine using ASTM-4595 Standard. Alternately the durability is also calculated by half life technique using mathematical expression of first order biodegradation kinetics, in which initial and reduction of tensile strength over a period of time is used as initial and final concentration of substrate respectively. The two values are then compared with actual field testing on newly laid Canal embankment to arrive at the optimum value.

Keywords

Paddy Straw Geomesh, Tensile strength and Durability, Biodegradation Kinetics, Half life, Embankment, Simulating accelerated biodegradation.

I. Introduction

The chemical composition of Paddy straw consists of 35-40% cellulose, 20-24% hemi-cellulose, 8-12% lignin, 14-16% ash and 10-12% extractives [1]. Although, paddy straw has high cellulose content but the lignin complex and silica incrustation shields the microbial action on the cellulose content and that is why it is not easily degradable. Due to this reason part of it is incorporated in the soil to retain plant nutrient and diverted for other uses also, but the measure quantity is often disposed of by conventional method like burning to cause serious air quality degradation. The Paddy straw produced in Bhandara District of Maharashtra State, India is proposed to be used as raw material for making Geomesh which would be laid on outer slopes of embankments with intermediate anchoring to control erosion. The making of Geo-mesh includes manual rolling of straw through palm of one hand and pushing by other hand and simultaneously plaiting the straw stems into handmade ropes/strands which is then converted into mesh with vertical and horizontal arrangement of strands. Such meshes fall into the category of Open Weave Textiles (OWTs) of Rolled Erosion control Product (RECP) as defined by ECTC. However since the OWTs are referred in India as Erosion control Meshes (ECMs) [2], the said mesh in this case is also labeled as Paddy Straw Geo-mesh. Since the Paddy Straw unlike other popular erosion control material like Jute and Coir, is not capable of producing fibre and yarn, therefore the manually made Paddy Straw is definitely going to have less tensile strength, durability and lower cost than OWTs / Geomeshes produced from fibre and yarn of both Jute and coir material. The details of some such RECPs that are available in the market and the proposed paddy straw Geomesh are shown in Fig.1

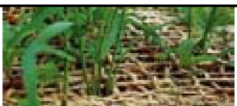
Photo of Geomesh	Material	Type as Per ECTC	Life in years	Manufacturer	Cost Rs sq. m.
	Jute (rope) woven mesh*	OWT (Called ECM in India)	1	Jute Manufacture's Development Council (JMDC), Kolkata	55/- (year 2014)
	Coir (rope) woven mesh*	OWT(Called ECM in India)	1-2	Charankattu Coir Mfg. Co. Ltd.Shrllay, Kerala	76/- @ (year 2014)
	Geo-mesh with plaited ropes of Straw(proposed)	OWT (Called ECM in India)	To be found out	Proposed by Authors	22/- (year 2014)

Fig.1: Different form of RECPs available in the market and proposed Paddy Straw for Erosion control.

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Since the paddy straw Geo-mesh while lying on slopes of embankment would come in close contact with embankment soil that invariably contain some chemical contaminations along with microorganisms, and under the effects of environmental factors like moisture, humidity, temperature and microbial would immediately undergo biodegradation. This process of Biodegradation in case of polymeric material is usually associated with changes in the physical, chemical and mechanical properties like reduction in weight and tensile strength of the material(Straw Geomesh in this case). Since the Geomesh is expected to survive at least one year to help in consolidating newly constructed embankment with the development of natural vegetation cover, the necessity to find durability of Geomesh gets created.

The methods of quantification of biodegradation of Polymer includes viz. Enzyme Assays, Plate tests, Biochemical Oxygen Demand (BOD) Test to measure the Degree of Biodegradation of the Test Material, Gas (CO_2or CH_4) evolution tests, Radioactively Labeled Polymers(Incorporation of radioactive 14C in synthetic polymers), Laboratory-scale Simulated Accelerating Environments and Natural Environments (Field Trials) [3].

Out of the above the last method is more popular in which the material to be tested is treated either chemically or microbiologically, under controlled laboratory conditions to undergo degradation which is then measured in terms of reduction in weight and tensile strength of the material over a period of time. These results are then compared with that of the same material that has undergone degradation (Also measured in terms of reduction in weight and tensile strength), under Natural Environments to arrive at the durability period. This method is effectively used for calculating durability of Coir [4]. The study included selection of two varieties of Coir yarn and which is then kept it in different soil media (in burial state also) and water in a humidity cabinet with a temp of $30 \pm 1^{0 \text{ and}}$ a relative humidity of 90 ± 1% .The degradation behavior is then delineated by conducting tensile strength tests at different intervals. The 100% loss of tensile strength on the day over specific period is considered as its life in days or durability period. The durability of the Jute is also found with similar method in the past [5] and [6].

Since the material to be effectively degraded in this case, is a paddy Straw, the different methods include Pretreatment of Paddy Straw with alkaline hydrolysis, acid hydrolysis, oxidative delignification and solvent extraction, Ammonia Fibre Explosion, CO2 and steam explosion and biological pretreatment strategies (lignocellulolytic microorganisms and the enzymes) are found to have been effectively used [7] and [8]. A similar biodegradation of Paddy Straw is observed by treating it with two cellulolytic and one lignolytic fungi (viz. Aspergillus awamori, Tracoderma reesei, and Phanerochaete Chrysosporium) amended with Nitrogen and Phosphorous which resulted into effective biodegradation of Paddy Straw[9,14].

Environmental aerobic biodegradation and half-life estimation of standard Chemicals using software "BIOWIN" is presented [15]. The technique involves finding out the value for biodegradation reported as the %BOD (Biochemical Oxygen Demand) or as the percentage of chemical degraded and then this information is converted to a half-life estimate using equation $C = C_0 \exp^{(-kt)}$------------------------------(1) Where 'e' is defined as the first order decay of an initial quantity C_0 to C in time t. This approach assumes first order decay and it does not allow for an initiation period during which the microbial community becomes activated or acclimated.

As found in most of the durability studies of the Lignocellulosic natural erosion control material (Paddy straw Geo-mesh in this case), the method proposed here includes Embedding Geo-mesh in a soil environment, created to be conducive, for undergoing biodegradation of the paddy straw Geomeshes due to combined process of Oxidation, chemical and biological degradation and then measuring the durability in terms of reduction in weight and tensile strength of the said Geo-mesh is selected. This result is then compared with result of calculation of durability of Geomesh obtained by testing under actual field conditions and additionally Calculated durability in terms of Half life of Geomesh using mathematical technique and expression of first order kinetics of biodegradation. The following experimental setup is proposed.

II. Material And Methods

Manually prepared Paddy straw Geo-meshes:

These meshes of 200x200 mm size with thickness of 6 mm with aperture size of 12x12 mm are obtained from village Bhandara in Maharashtra for the proposed experiment. Out of prepared 80 samples, only those 54 samples that Possessed tensile strength equal to 8.0 kN/m with appropriate size as mentioned above, were separated from the lot after actual testing on textile testing machine in the laboratory.

Soils for Embedment:

Soft murum which is generally used as a shell material for embankment and occasionally used Red soil free of dirt etc. are obtained from Local Different Nursery in Pune.

Chemicals and Fungi culture:

Dilute H_2SO_4 and NaOH (to be used to adjust and maintain three pH ranges viz.5.5, 7.0 and 8.5), Distilled water, Small doses of fertilizer Urea (48% Nitrogen) and Ammonium Super phosphate (3-6% Nitrogen & 48-53% Phosphorous) to be used to decrease C: N ratio of soil interface is made available by Biotechnology Department of Ferguson college, Pune.

Procurement of Fungi Culture:

The Fungi culture of two cellulolytic fungi called Aspergillus awamori + Tracoderma Viridae in the proper Proportion (i.e. spore no 10^8 /ml i.e. 100 ml pertains to $10^{10}$of each Aspergillus awamori + Tracoderma Viridae) which would help in increasing the biodegradability of paddy straw. Out of these three, the cellulolytic fungi, Tracoderma Viridae is considered to be more effective.

Misc. Equipments:

Plastic Boxes(150x350x200 mm) to retain 6 no. of Geomeshes with 10 mm soil layer in between, Different size sieves, Thermometer, Trays, Weighing balance and Geotextile Tensile testing machine. The material like chemicals, fungi

Culture mentioned under last three heads was made available Biotechnology Department of Ferguson College, Pune where the experimental setup was done for taking trials.

Table 1: Literature properties of Paddy straw and Experimental properties of two soils

S.N.	Parameter	Literature Properties Paddy straw	Properties of two type of soils used for embedment		Remark
			Reddish brown Value/Rating	Soft Murum Value/Rating	
1	pH (1:2.5)	7.2	8.54(Strong alkaline)	7.33 Neutral	Important
2	Electrical conductivity (dSm-1)	3.58	(Neutral)	(Neutral)	Siemens/m
3	Toc (%)	44.82	0.17(Very low)	0.48(Medium)	
4	Available Nitrogen (%)	0.49	69.0(Very low)	13.0(Very low)	
6	Available phosphorus (%)	0.1	5.82(Very low)	3.33(Very low)	
7	Hydraulic Conductivity	--	7.55(Rapid)	2.2(Moderate)	(cm/hr)
8	Bulk density	--	1.33	1.32	(Mg/cum)
9	Max. Water holding capacity (%)	--	33.68	48.2	
10	Sand (%)	--	66.75	48.2	

Table 2: shows details of embedded environment and effect on Paddy Straw Geomesh over time period.

Name	Embedded Environment (pH) (3 set of each category)	Final pH of mixture	Remark
S-1	Geo-mesh(7.0)+ Water(7.0)	7.0	1) The Red soil with initial pH of 4.5 is found to possess buffering capacity for increase in pH from 4.5 to desired pH ranges of 5.5, 7.0 and 8.5. 2) Very small doses of Urea and Phosphate do not affect pH of mixture. 3) The addition of fungi culture does not affect pH of the mixture. 4) N60P60 related to Nitrogen by Urea and Phosphorous by Phosphate.
S-2	Geo-mesh(7.0) + Water(7.0)+ Red soil(4.5)	5.5	
S-3	Geo-mesh(7.0) + Water(7.0) + Soft Murom(7.0)	7.0	
S-4	S-2 + Dil. H_2SO_4 (5.5) + N60P60+ Culture	5.5	
S-5	S-3 + Dil. H_2SO_4 (5.5) +N60P60+ Culture	5.5	
S-6	S-2+ NaOH (8.5) + N60P60+ Culture	8.5	
S-7	S-3+ NaOH (8.5) + N60P60+ Culture	8.5	
S-8	S-2+ Dil. H_2SO_4 /NaOH (7) + N60P60+ Culture	7.0	
S-9	S-3+ Dil. H_2SO_4 /NaOH (7) + N60P60+ Culture	7.0	

III. Experimental Method

The scope of work is limited to assess the durability of Paddy Straw Geomesh expressed in days in terms of the reduction in weight and tensile strength of the paddy straw Geomeshes, under different embedment conditions over a period of time and comparing results with that found by mathematical calculations and actual field trials. Accordingly the experimental work was divided in following phases.

Phase1**:**

The basic physical and chemical properties like pH, Total organic carbon(TOC),available Nitrogen and Phosphorous etc. of Paddy straw Geo-mesh and embedment material like Soft murum and Red soil samples are tested in the in the laboratory and the results are tabulated in Table 1 below.

Phase 2:

The initial weights and tensile strength of the Geomeshes (1 set of 3 samples for each 9 embedment) was found out respectively on electronic balance and textile testing machine before the experiment.

Phase3:

About 9 (nine) different embedment (i.e.1 set of 3 samples for each 9embedment), were prepared using two types of soils viz. Soft murum and Red soil as described in

Phase 4:

In all 27 boxes (3x9) are taken i.e. the 3(three) boxes of each 9(nine) embedment environment and each box would contain about 6(six) Paddy Straw Geomeshes deeply buried into embedment. These 9 (nine) different embedment environment conditions are created in the laboratory using murum and Red Soil mixed with Urea, Ammonium Phosphate and the fungi culture i.e. Spore no 10^8 /ml i.e. 100 ml pertains to 10^{10} of each Aspergillus awamori + Tracoderma Viridae is mixed in Red and Black soil in specific proportion as mentioned in Table 2. The photographs are given in Figure 2.

Phase 5:

The Paddy Straw Geo-mesh samples are now buried into this embedment. Care is taken to keep the conditions wet by adding water periodically into these boxes until the end of first 15(fifteen) days, when 1(one) samples of Paddy Straw Geo-mesh is taken out from each 3(three) boxes of each of the 9(nine) embedment, cleaned with tap water and dried at room temperature and then its residual weight and tensile strength is measured on weigh balance and Textile testing machine respectively. The process is repeated at the end of each 30,45,60,75, and 90 days. The reduction in weight and tensile strength at the end of each 15, 30,45,60,75 and 90 days under different embedment is calculated every time

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till the residual tensile strength has equaled 0.10 kN/m and the proportionate period are considered as life of Geo-mesh. The detailed observations are plotted in Fig.3 and 4.

Phase 6:

The durability of Paddy Straw Geo-mesh is also calculated using expression of first order kinetics of biodegradation and half life calculation. Generally half life of a product is calculated at its 50% residual strength at a corresponding time 't" (days). However, in this case, it is observed that since there is a considerable difference between initial and yardstick tensile strength of 8.0 kN/m and 1.0kN/m of Paddy Straw Geo-mesh respectively, several half life might be calculated with respect to time "t" in days using equation (1) above i.e. $C_t = C_0 \ e^{-k}$; Where C_0 = Initial tensile strength of the Paddy Straw Geo-mesh; C_t = Residual tensile strength of the Paddy Straw Geo-mesh at time t; k= Rate constant in days and t = time in days.

1: Known weight of Red soil & murum	2: Geo-mesh is weighed on balance.	3: View of 6 Geomeshes in box.	4: Geomesh before the experiment	5: Disintegrated Geo-mesh after 75 days.	6:Geomeshes tested for tensile strength

Fig. 2: Study of Biodegradability experiment of Paddy Straw Geomesh

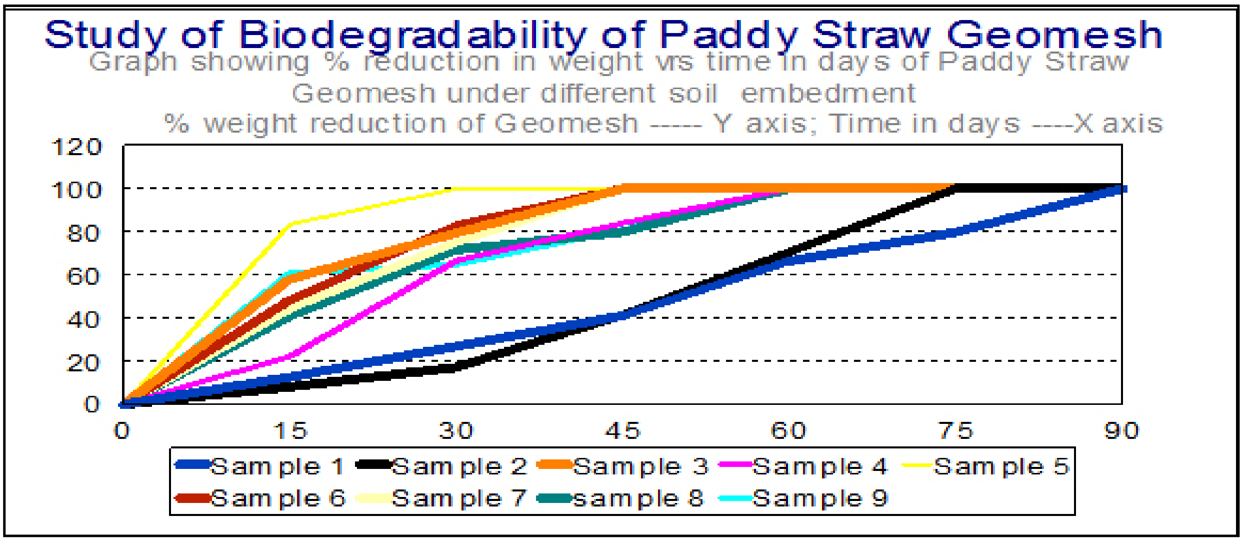


Fig. 3: % reduction in weight (Y axis) vrs Time in days(X axis)

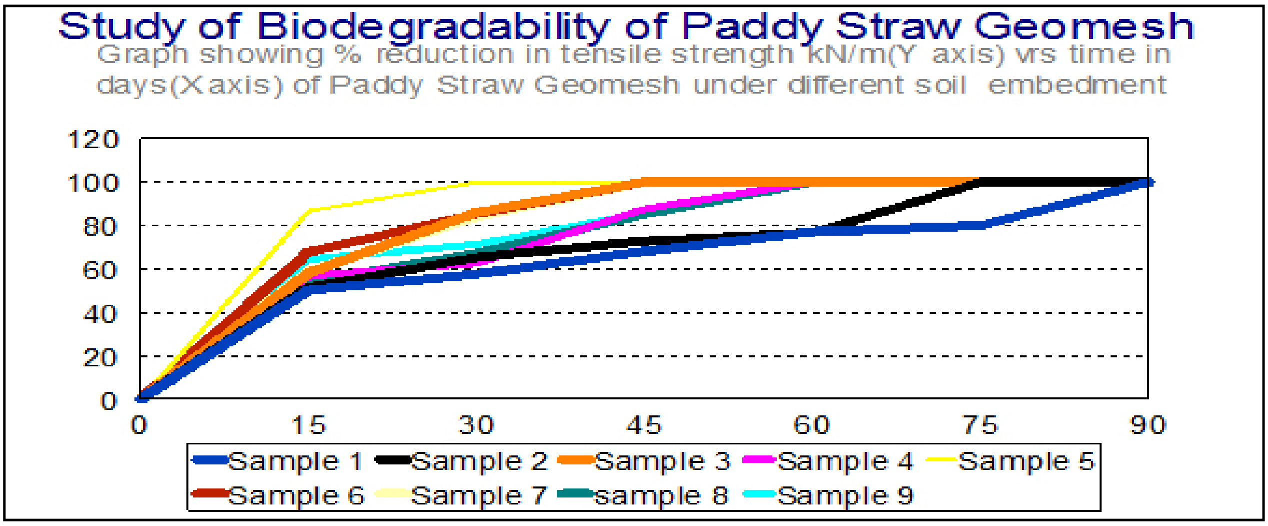
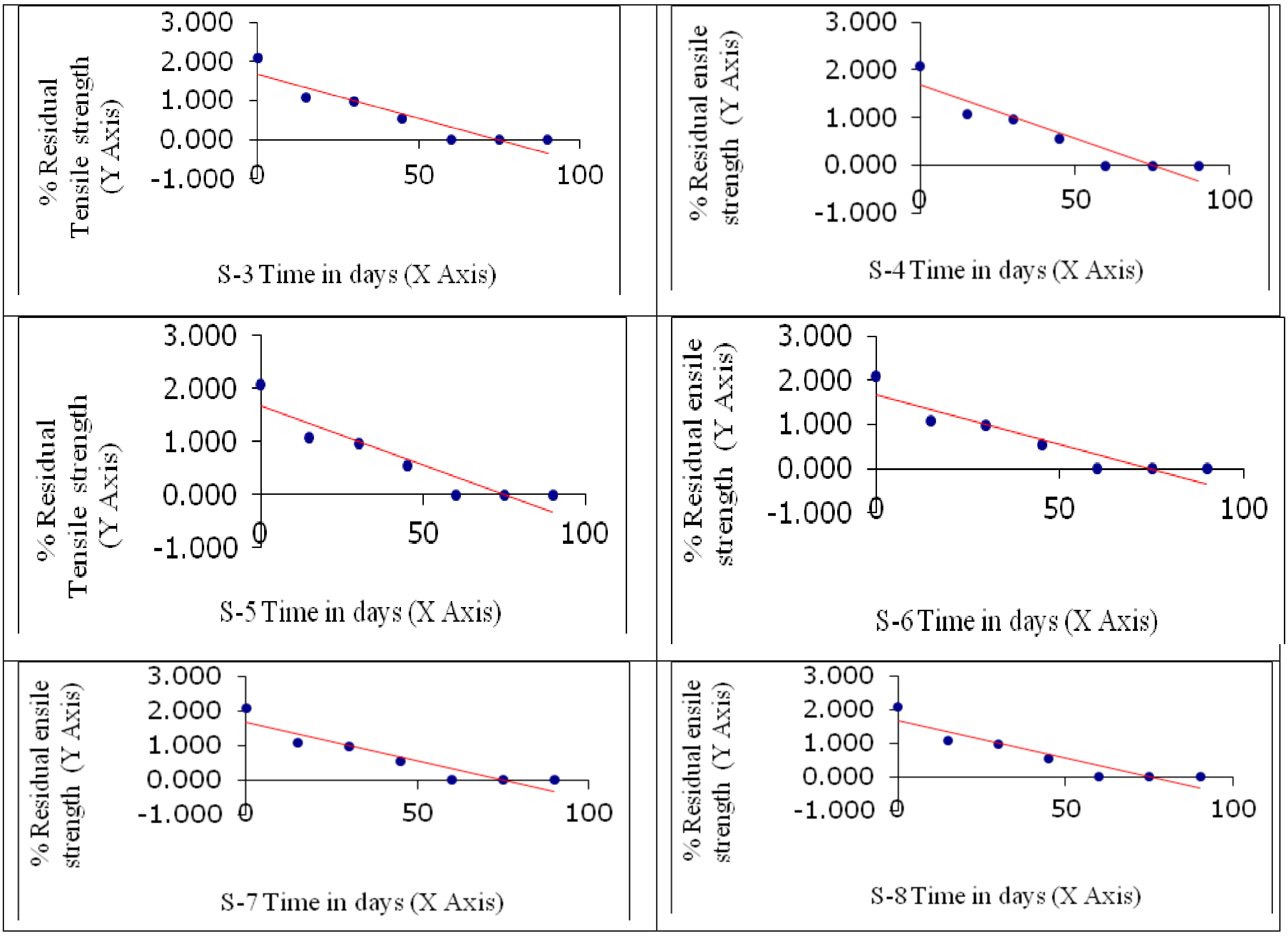
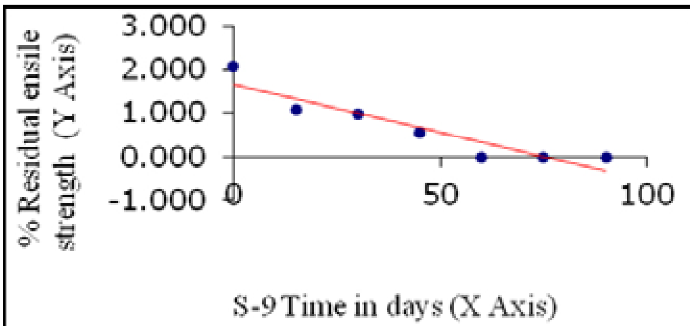


Fig. 4: % reduction in tensile strength (Y axis) vrs Time in days(X axis)

Phase 7:
The reaction rate is calculated by plotting a graph between natural logarithm of tensile strength at the time t(in days) on y axis vrs time in days on x axis .The nature of the graph is a straight line and therefore it may prove that the assumption of the reaction to be of first order. The slope of the best fit line gives the biodegradation rate constant (-k) and using that the half life of the Paddy Straw Geo-mesh is calculated using equation; $T_{1/2}$=0.693 k. The reaction rate in this case, is calculated using statistical method of data analysis for Linear Correlation and Regression between the treatments given for different embedment using software "Vassar Stats" freely available on internet. The results are tabulated in Fig.5.





Note: Although the biodegradability data does not fit well into the first order kinetic model, the higher correlation coefficient observed between sample 1, 2, 4 and 9 shows some relationship between time in days and reduction in tensile strength of the Paddy Straw Geo-mesh under different embedment.

Sample	Correlation R^2	Rate constant = Slope 'k'	Numerical 'K'	Half life (Days) $t_{1/2}$ = NL 2/ k = 0.69/k
1	0.949	-0.025	0.025	27.60
2	0.899	-0.021	0.021	32.86
3	0.285	-0.0137	0.0137	50.36
4	0.819	-0.021	0.021	32.86
5	0.225	-0.0123	0.0123	56.10
6	0.347	-0.0145	0.0145	47.59
7	0.686	-0.0674	0.0674	10.24
8	0.714	-0.0241	0.0241	28.63
9	0.869	-0.0223	0.0223	30.94

Fig.5: Plot shows best fit line to establish linear correlation and Regression between Tensile strength of 9 (nine) samples of Paddy Straw Geomesh and Days

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Phase 8: The above two results of durability of Geo-mesh calculated respectively by laboratory experiment, and mathematical expression are now compared with field trial results. The Geo-mesh is kept on the newly constructed embankment on portion of Pench canal near village khat, District- Nagpur, Maharashtra, India and reduction in tensile strength are observed every month for three month. The details are shown in Fig.6.

		
1.0 Paddy straw Geomesh laid on dated 7/06/2013. Tensile Strength (200x200 mm piece cut and tested) = 8.103 kN/m	**2.0** Same embankment as observed on dated 07/07/2013; Tensile Strength (200x200 mm piece cut and tested) = 3.24 kN/m (% Reduction=60%)	3.0 Same embankment as on dated 07/08/2013.Geomesh disintegrated but consolidated the embankment Tensile Strength (200x200 mm piece cut and tested) = 1.24 kN/m (% Reduction= 84.69 %)

Fig. 6: Shows field studies of Biodegradability of Paddy Straw Geo-mesh laid over Canal outer embankment

IV. Result And Discussion

Experimental durability Calculation

The durability is first calculated from Biodegradation expressed in terms of % reduction in weight plotted against time in days in the Graph (Fig.3). It shows that the Bio-degradation of paddy Straw Geomesh is observed to be more in murum than in red soil. This is observed in case Sample no.S-5 (pH-5.5) and S-3(pH-7) in murum which have degraded faster than similar conditioned Sample no.S-4(pH-5.50) and S-2(5.5) in Red soil. Although both murum and Red soil have more or less same low % of Nitrogen and Phosphorous as per Table-1 and doses of Urea, Ammonium Superphosphate and culture added during the experiment, in all Samples except Sample S-1, S-2 and S-3 are same, the degradation rate in case of Sample no.S-5(15days) in murum is almost double than the similar conditioned Sample no.S-4(pH-5.50) in Red soil.

The Graph (Fig.4) of % reduction in tensile strength of Geomesh vrs time in days also shows that the Bio-degradation of paddy Straw Geomesh has occurred more in murum than in red soil as described above. The durability of the samples is considered as no. of days for which the given sample has survived in the medium till its strength does not go down than that of yardstick.

In the initial period (up to 15 days) bio-degradation is very rapid (linear). It then slows down (stabilizes-plateau region) up to about 45 days and then again degrades rapidly in the next 15 days (Sample 1, 2, 4). The tensile strength of the Geo-mesh is still greater than 2.0 kN/m up to and about 45 days. Further the reduction in tensile strength is linear since the graph between log natural (LN) of tensile strength vs. time is not linear (Fig. 5). A very rapid degradation is observed with pH variation for samples 4, 6, and 8 in alkaline medium.

The combined effect of chemical degradation and biodegradation is also quantified by studying beheavier of samples S-3, S-5, S-7 and S-9 in Graph.4. It is also observed that the degradation of Paddy straw has predominantly occurred due to fungal biodegradation rather than chemical degradation. The sample S-3contains Murom only with pH 7.0, while sample S-5, S-7 and S-9 contains murum plus fungi culture with chemicals to adjust different pH, but still the durability period for sample S-3 is 30 days i.e. almost at par with sample S-5(15 days), S-7(30 days) and S-9(45 days).

.Furthermore the murum used is collected from the field and used directly without any disinfection treatment like autoclaving etc. The experiment is carried out under controlled condition of temperature (32^{o}C. in the month of March, April and May 2013) and all samples in wet condition. Therefore, the said Murom itself may contain microbial or fungi culture which may be responsible for early biodegradation of Paddy Straw Geomesh which is found to have enhanced in other Murom samples due to addition of chemicals and fungi culture separately. Since the Strata used for construction of casing of the embankment is invariably Murom only, the field biodegradation rate of the Paddy Straw Geomesh when laid on Embankment of either Dam or Canal in open atmosphere condition would be much higher.

Calculation of Half life of Geomesh using first order Biodegradation Rate constant:

The reaction rate is calculated by plotting a graph between natural logarithm of tensile strength at the time t(in days) on y axis vrs time in days on x axis and using expression equation (1) i.e. $C = C_0 \exp^{(-kt)}$ i. e, first order decay from an initial quantity C_0 to C in time t . This approach assumes first order decay and it does not allow for an initiation period during which the microbial community becomes activated or acclimated. The calculated half life values are shown in table within Fig 5.

The mathematically calculated values of half life are not consistent with that of first method and third method of accelerated laboratory biodegradation (4.1) and field experiment results (4.3) respectively. This may be due to calculation of rate constant (k) value by using reduction in tensile strength of a Geo-mesh as a substitute for concentration of the medium/embedment or BOD, which is a parameter generally used for calculating half life of the Product.

Calculation of durability of Geomesh using field experiments:

The Paddy straw Geomesh laid on the newly constructed embankment of Pench Canal near village Khat, Taluka and district Nagpur, Maharashtra, India under exposed natural environment conditions shows the durability of Paddy Straw Geomesh to be 60days (Two months).The Geomesh is simply laid and tied down to surface by "U" shaped M.S. bars without any overburden of embankment soil which is a combination of murum and medium black soil. The microorganism within the soil appears to have caused biodegradation of Geomesh.

The comparative chart showing durability of Paddy Straw Geomesh calculated by three methods viz. Reduction in tensile strength by accelerated biodegradation, 1st order biodegradability rate constant and half life estimation and Field trials on newly constructed embankment of canal is presented in Table 3 below.

Table 3: Shows Life of a Paddy Straw Geo-mesh by three methods

Sample No.	Durability in days on the basis of Reduction in tensile strength by accelerated biodegradation 1st order biodegradability rate constant and half life estimation Field trials on newly constructed embankment of canal					
	1st case		2nd case		3rd case	
	Life	Remark	Life	Remark	Life	Remark
1	**75 days**	**Maximum**	34.67 days	-	**60 days**	Geo-mesh laid on canal embankment on dated 7/6/2013 and was able to strengthen the embankment till 7/8/2013 with residual tensile strength of 1.24kN/m
2	60 days	-	32.39 days	-		
3	30 days	-	49.64 days	-		
4	45 days	-	32.39 days	-		
5	**15 days**	**Minimum**	**54.76** days	**Maximum**		
6	30 days	-	46.62 days	-		
7	30 days	-	39.20 days	-		
8	30 days	-	**28.40** days	**Minimum**		
9	45 days	-	30.53 days	-		

V. Conclusion

The durability of Paddy Straw Geomesh calculated by above three methods appears to be limited to maximum Two to two and half months only which is a sufficient period for establishment of good vegetation cover to control erosion of the embankment. The degradation of Paddy straw predominantly occurs due to fungal biodegradation rather than chemical degradation. The drastic reduction in the tensile test values of Sample 4, 6, and 8 over a period of time indicates that there is a very rapid degradation due to variation in pH of samples 4, 6, and 8 in alkaline medium The maximum value of durability period in days obtained by field testing is found to be nearly matching those calculated by the other two methods and hence this indicates that barring microbial degradation there is no significant effect of other factors like ambient temperature, soil type, moisture etc. The further repetition of experimentation will increase the consistency level of the results.

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References:

[1]. Bhatia, S., Rao, G. and smith, J. (2007) "international practices and guidance: natural-fibre rolled erosion conrol products" journal of scour and erosion, 231-240.

[2]. Jain, A. (1997) "Correlation models for predicting heating values through biomass characteristics" Journal of Agricultural Engineering 34, 12-25.

[3]. Saratale, G., Chen, S., Lo, Y., Saratale, R. and Chang, J. (2008) "Outlook of Biohydrogen production from Lignocellulosic feedstock using dark fermentation-a review". Journal of scientific and industrial research 67, 962-979.

[4]. Balan, K. And Venkatappa Rao, G. (2000). Durability of Coir Yarn For Use in Geomeshes, Coir Geotextile-Emerging Trends, Avenir Printers, New Delhi, Page No 68 -79.

[5]. Saha, P., Roy, D. , Manna, S., Adhikari, B., Sen, R., Roy, S. "Durability of transesterified jute Geotextile" Geotextile and Geomembranes 35 (2012) 69e75,2012, 60-75

[6]. Abdullah, A.B.M, Dr. (2008), Jute Geotextile and their applications, jute diversification promotion centre (JDPC) 145, Monipuripara, Tejgaon, Dhaka.

[7]. Hendriks, A. and Zeeman, G. (2009)" Pretreatments to enhance the digestibility of Lignocellulosic biomass" Bioresource technology 100, 10-18.

[8]. Basti, C. (1998) "Handbook of Biodegradable polymer" Rapra Technology Limited, Shawbury, Shropshire, SY4 4NR, United Kingdom Telephone: +44 (0)1939 250383, 1.5-1.5.1 - 1.5.7, 11 – 20.

[9]. Phutela1, U., Sahni, N., and Sooch, S. (2011)" Fungal degradation of paddy straw for enhancing biogas production" Indian Journal of Science and Technology Vol. 4 No. 6, ISSN: 0974- 6846.

[10]. Gaind, S. and Nain, L.(2011) " Soil Health in Response to Bio-Augmented Paddy Straw Compost" World Journal of Agricultural Sciences 7 (4), 2011, 480-488, ISSN 1817-3047.

[11]. Castro, A. De, Castilho, T., and Freire, D. (2010) "Use of mesophilic fungal amylases produced by solid state fermentation in the cold hydrolysis of raw babassu cake starch" Applied Biochemistry Biotechnology. 162: 1612-1625.

[12]. Reanprayoon, P. and Pathomsiriwong, W. (2012,) "Tropical Soil Fungi cellulose and related enzymes in biodegradation" Journal of Applied Sciences12 (18), 1909-1916.

ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

[13]. Zhuxz, H. and Xang, X.(2009) " Effect of simulated acid rain on decomposition of soil, organic carbon and crop straw" College of Resources of Environmental Sciences, Nanjing Agricultural University, Nanjing 20 (2) , 480-4

[14]. Agarry, S. And Jimoda, L. (2013) "Application of Carbon-Nitrogen Supplementation from Plant and Animal Sources in In-situ Soil Bioremediation of Diesel Oil: Experimental Analysis and Kinetic Modeling" Journal of Environment and Earth Science www.iiste.org,ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol. 3, No.7, 51.

[15]. Arnot, J., Gouin, T. and Mackay, D. (2005)" Development and Application of Models of Chemical Fate in Canada Practical Methods for Estimating Environmental Biodegradation Rates" Report to Environment Canada. CEMN Report No. 200503. Prepared by: Canadian Environmental Modeling Network, Trent University, and Peterborough, Ontario K9J 7B8, Canada. , 4-5.