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Aviskaar

A Xaverian Journal of Research


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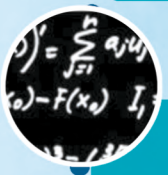
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Physical Science


Biological Science

St. Xavier's College
(Autonomous)

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The Principal
ST. XAVIER'S COLLEGE
(Autonomous)

30 Mother Teresa Sarani, (Park Street)
Kolkata - 700 016

1 December 2015

MESSAGE

It gives me great pleasure in introducing the eighth volume of **"Aviskaar-A Xaverian Journal of Research."**

This volume contains contributions from different departments like Physics, Microbiology, Management, English and Commerce. It is a harvest of research carries out by the students and teachers in collaboration with other institutions.

In this connection I am happy to declare that four departments of our College namely, Biotechnology, Physics, Microbiology and Commerce have been granted permission by the University of Calcutta to carry our Ph.D. Programme.

It is my firm conviction that this traditin will continue and in future there will be meaningful contributions from other departments of the College.

I congratulate the Editorial team and the Contributors for this volume.

I take this opportunity to wish you all 'A Grace filled Christmas and a Prosperous New Year 2016'

Rev. Dr. John Felix Raj, S.J.
Principal
St. Xavier's College
(Autonomous)
Kolkata-700 016

From the Editor's Desk

The Journal of Aviskaar has now reached the eight year of publication. This year, there have been contributions from the departments of Physics, Microbiology, Management, History and English, which clearly indicate the multidisciplinary nature of the journal. The research culture is growing in this institution and four departments in the form of Biotechnology, Commerce, Microbiology and Physics has already been accredited with the power of carrying out Ph.D. program by the Calcutta University. The paper on Physics is on time variation of Gravitational Constant. The papers on Microbiology has addressed a very important issue of marine pollution by detergent, in this case it is by a bacteria called *Brevibacillus,* pollution of plastic is a burning issue and it is being treated by a mould isolated from municipal waste. The paper from management deals with gender inequality problem in India. The paper on History has revisited the issue of environmental sanitation in colonial Bengal with respect to epidemic diseases. The paper from English Department discusses the issue of tracking tigers through literatures on wildlife.The last paper is on the impact of chromium toxicity on *Channa punctatus* and is actually a product of research collaboration with the Department of Zoology, Vidyasagar College.

I strongly believe that this issue of Aviskaar will uphold the Research environment of this intitution.

Dr. Arup Kumar Mitra,
Associate Professor & Editor, Xaverian Journal of Research
Post Graduate Department of Microbiology,
St. Xavier's College, Kolkata - 16

List of Professor who obtained the Ph.D. degrees during the year 2015

Awarded Ph.D.

Dr. Mohsin Islam	Commerce(E) (Maths & Stats)
Saswati Chowdhury	Commerce (Morning) (Economics)
Kaushik Kumar Hati	Commerce (St. Lawrence) (Economics)
Nilanjan Sen	Commerce (Morning) (Economics)

Stamement of Grants Received During Jan to Mar 2015

Sl No	Date of Receipt	Name of the Grant/ Sanctioning Body	Teachers' Name	Dept.	Amount (Rs.)
1.	10.01.2015	**DBT (WB) GT**	Dr. Chandana Barat	Bio-tech	₹ 3,82,288
2.	21.01.2015	**Jessuit Eruopean Social Centre**	Global Earth Summit	Fr. Xavier	₹ 918604.80
3.	28.01.2015	**UGC Autonomy Grant**	College of 12-13	College	₹ 1000000
	28.01.2015		College of 13-14		₹ 400000
	28.01.2015		College of 13-14		₹ 1,600,000
	29.01.2015		College of 14-15		₹ 600,000
	29.01.2015		College of 14-15		₹ 1,000,000
	02.03.2015		College of 15-16		₹ 1,600,000
					₹ **6,200,000**
4.	09.02.2015	**ICAR Grant**	Dr. D Chakraborty	Bio-tech	₹ 5,83,590
5.	19.02.2015	**Higher Education Dept(WB) Sanghati**	Dr. S L Choudhury	Sociology	₹ 3,00,000
6.	25.02.2015	**UGC minor Reseach Project**	Sonali Sen	Comp.Sc	₹ 3,57,400
	25.02.2015		Dr. Kasturi Sarkar	Mbiology	₹ 3,15,000
	27.02.2015		Soumi Bhattacharya	B.com eve	₹ 1,60.000
	27.02.2015		Soumya Saha	M.com	₹ 1,50,000
	27.02.2015		Sukanya Sarkhel	BBA	₹ 1,55,000
7.	23.03.2015	**Indian council of SSC**	Symposium/SK Basu	M.com	₹ 50,000
8.	17.03.2015	**National Human Rights Commission**	1 Day training Program	Pol. Sc.	₹ 42,817
				TOTAL	**₹ 9,61,4699**

Stamement of Grants Received During April to November 2015

Sl No	Date of Receipt	Name of the Grant/ Sanctioning Body	Teachers' Name	Dept.	Amount (Rs.)
1.	07.04.2015	**UGC minor Reseach**	Dr. Anindita Banerjee	Microbiology	₹ 2,60,000
	16.07.2015		Dr. Sudipa Saha	Bio-tech	₹ 33,000
	16.07.2015		Dr. Uma Siddanta	Bio-tech	₹ 35200
2.	14.05.2015	**CSIR Grant**	Sonia Bedi	Project Fellow	₹ 1,02,500
	17.10.2015		Dr. Aryadeep Roy Choudhury	Bio-tech	₹ 4,45.078
	13.10.2015		Dr. Ronita Nag Choudhri	Bio-tech	₹ 7,66,000]
	17.10.2015		Dr. Surupa Chakraborti	Physic	₹ 72,950
3.	24.11.2015	**DAE/BRNS**	Dr. Jhimli Dasgupta	Microbiology	₹ 7,98,379
4.	27.05.2015	**DBT GOI FOR STAR College**	College	College	₹ 22,00,000
5.	10.04.2015	**DBT WB Project**	Dr. Uma Siddanta	Bio-tech	₹ 19,96,800
6.	16.10.2015	**DST-SERB GRANT**	Dr. Aryadeep Roy Choudhuri	Bio-tech	₹ 1,45,000
	20.11.2015		Dipankar Charkaborty	Bio-tech	₹ 3,45,144
7.	16.09.2015	**DST GOI+DC**	Dr. Arup Mitra	Microbiology	₹ 50,000
8.	23.09.2015	**DST WB GRANT**	Dr. Anirudha Banerjee	Bio-tech	₹ 4,81,700
					7,73,1751
9.	17.08.2015	**ICAR GRANT**	Dr. Dipankar Chakrabory 15-16	Bio-tech	₹ 4,31,371
10.	01.09.2015	**ICMR GT**	Dr. Maitree Biswas	Project Fellow	₹ 2,49,258
11.	04.08.2015	**ICSSR GRANT FOR WORKSHOP**	Workshop	Sociology	₹ 4,05,000
12.	16.09.2015	**RUSA GRANT**		College	₹ 50,00,000
13.	21.08.2015	**UGC JRF GRANT W.B.**	Dr. Saiket Paul	Project Fellow	₹ 3,06,000
14.	24.08.2015	**WBTDCC**	Santalhul	AICUF	₹ 10,000
15.	03.09.2015	**Calcutta University**		NSS	₹ 28,500
16.	19.08.2015 12.10.2015	**UGC Travel Grant**	Dr. Tapati Dutta Dr. S.S. Saha	Physics B. Com(m)	₹ 2,43,850 ₹ 77,825
				TOTAL	**₹ 14,483,555**

Time Variation of Gravitational Constant and Deceleration Parameter : A Theoretical Model Based on Brans-Dicke Theory

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Abstract

A simple ansatz has been chosen for the Brans-Dicke(BD) scalar field ϕ where it has been shown to have the same dependence upon scale factor as that of the density of matter (ρ) of the universe. The present model is based on the generalized BD theory where the BD parameter ω is regarded as a function of the scalar field ϕ . Solving the field equations for a spatially flat Robertson-Walker space-time, the functional forms of a(t),q(t), H(t), G(t) have been determined and their inter-dependence has been analyzed in detail. The parameter $\omega(\varphi)$ has been found to have a negative value. The possibility of an inter-conversion between dark energy and matter has been taken into account by introducing a slowly varying function. A signature flip of deceleration parameter and an increase of gravitational constant with time have been found in the present study.Thetime dependence and inter-dependence of the relevant parameters have been explored both analytically as well as through numerical plots.

Keywords: Brans-Dicke theory; Accelerated expansion of the universe; Gravitational constant; Dark energy; Brans-Dicke scalar field; Sinature flip of deceleration parameter; Cosmology

Introduction

Recent observations regarding the expansion of the universeconfirm that the universe has undergone a smooth transition from a decelerated to an accelerated phase of expansion [1,2]. Since normal matter has a positive definite density and pressure and gravitates in the usual manner, there must be some other kind of matter responsible for the observed acceleration, which makes the effective pressure sufficiently negative and gives rise to a repulsive effect. Such kind of matter is popularly known to be the 'Dark Energy'. Much attention has been

devoted in past years to analyze the nature of it. A long list of models has evolved with an attempt to explain the acceleration to be ascertained.

Cosmological constant is the simplest choice forthe dark energy [3]. CDM model has a serious drawback in connection to the value of cosmological constant Λ. The currently observed value of Cosmological constant Λ for an accelerating Universe does not match with that of the value in Planck scale or Electroweak scale [4]. The problem can be rendered less acute if one tries to construct dark energy models with a time dependent cosmological parameter. Many such models have been proposed but they have their own problems [5, 6].

A suitable alternative to the dynamical Λ models are the scalar field models in which the equation of state of dark energy changes with time. Among the many proposed scalar field models, quintessence models are the ones endowed with a potential so that the contribution to the pressure sector, $P=\frac{1}{2}\varphi^2 - V(\varphi)$, can evolve to attain an adequately large negative value, thus generating the observed cosmic acceleration [7, 8]. One main drawback of these quintessence models is that most of the quintessence potentials are chosen arbitrarily and do not have a proper theoretical justification explaining their genesis. Naturally a large number of other alternative scalar field models, for example the tachyon [9, 10], k-essence [11, 12], holographic [13, 14] dark energy models have appeared in the literature with their own virtues and shortcomings.

In most of the scalar field models the cold dark matter and dark energy are normally allowed to evolve independently. However, there are attempts to include an interaction amongst them so that one grows at the expense of the other [15]. Non minimal coupling of the scalar field with the dark matter sector through an interference term in the action has helped in explaining the cosmic acceleration. Such fields are called 'Chameleon fields' and they have proved to be useful in playing the role of dark energy candidates [16, 17].

Non minimal coupling between the scalar field and geometry, especially in the frame work of Brans-Dicke theory, also pose themselves as possible candidates for explaining the observed acceleration. Modification of the Brans-Dicke(BD) theory by adding a potential $V(\varphi)$, which is a function of the BD scalar field itself, can serve as models explaining the acceleration of the Universe [18].

BD theory of cosmology has been analyzed with the aid of different models. To name a few, Sheykhi et al. [19] worked with the power-law entropy-corrected version of BD theory defined by a scalar field and a coupling function. In another literature Sheykhi et al. [20] considered the HDE model in BD theory to think about the BD scalar field as a possible candidate for producing cosmic acceleration without invoking auxiliary fields or exotic matter considering the logarithmic correction to the entropy. Jamil et. al. [21] studied the cosmic evolution in Brans-Dicke chameleon cosmology. Pasqua and Khomenko [22] studied the interacting logarithmic entropy-corrected HDE model in BD cosmology with IR cut-off given by the average radius of the Ricci scalar curvature.

Some models have also been suggested where a quintessence scalar field introduced in the BD theory can give rise to a late time acceleration for a wide range of potentials [23]. An interaction between dark matter and the BD scalar field showed that the matter dominated era can have a transition from a decelerated to an accelerated expansion without any additional potential [24]. On the other hand BD scalar field alone can also drive the acceleration without any quintessence matter or any interaction between BD field and dark matter [25].

However, the problem with many of these models is that the matter dominated Universe has an ever accelerating expansion contrary to the observations. Besides this, in order to explain the recent acceleration many of the models require a very low value of the BD parameter of the order of unity whereas the local astronomical experiments demand a very high value of ω [26].

In our present study we shall consider two different models, one with a variable Brans-Dicke parameter ω which depends upon scalar field parameter φ and the other model includes a constant BD parameter. In both these models we consider the dependences of cosmological parameters like Hubble parameter (H), scale factor (a), deceleration parameter (q), BD parameter (ω) and scalar field (φ) etc. on cosmological time as well as their interdependences.

Theoretical Model

For a spatially flat Robertson-Walker space-time, the field equations in the generalized Brans-Dicke theory are [27]

$$3\left(\frac{\dot{a}}{a}\right)^2=\frac{\rho}{\varphi}+\frac{\omega(\varphi)}{2}\left(\frac{\dot{\varphi}}{\varphi}\right)-3\frac{\dot{a}}{a}\frac{\dot{\varphi}}{\varphi} \tag{1}$$

$$2\frac{\ddot{a}}{a}+\left(\frac{\dot{a}}{a}\right)^2=-\frac{\omega(\varphi)}{2}\left(\frac{\dot{\varphi}}{\varphi}\right)^2-2\frac{\dot{a}}{a}\frac{\dot{\varphi}}{\varphi}-\frac{\ddot{\varphi}}{\varphi} \tag{2}$$

Combining (1) and (2) one gets,

$$2\frac{\ddot{a}}{a}+4\left(\frac{\dot{a}}{a}\right)^2=\frac{\rho}{\varphi}-5\frac{\dot{a}}{a}\frac{\dot{\varphi}}{\varphi}=\frac{\ddot{\varphi}}{\varphi}. \tag{3}$$

Considering the conservation of matter of the universe we propose the following relation.

$$\rho=f(t)(\rho_0 a_0^3)a^{-3}=f(t)\rho_0 a^{-3},(a_0=1) \tag{4}$$

Here a_0 are ρ_0 the scale factor and the matter density of the universe respectively at the present time. The reason for introducing the factor $f(t)$ is that the matter content of the universe may not remain proportional to $\rho_0 a_0^3$ [31]. There may be an inter-conversion between dark energy and matter (both baryonic and dark matter). It is assumed here that this conversion, if there is any, is extremely slow. In the present model therefore, the factor $f(t)$ is taken as a very slowly varying function of time, in comparison with the scale factor, and $f(t) = 1$ at $t = t_0$ where t_0 denotes the present instant of time when the scale factor $a = a_0 = 1$.

To make the differential equation (3) tractable, let us propose the following ansatz.

$$\varphi=\varphi_0 a^{-3} \tag{5}$$

This choice of φ makes the first term on the right hand side of equation (3) independent of the scale factor (a). In equation (5) we have taken $\varphi=\varphi_0$ for $a = a_0 = 1$.

Combining (3) and (5)and treating f as a constant we have,

$$\frac{\ddot{a}}{a}-\left(\frac{\dot{a}}{a}\right)^2=-f\frac{\rho_0}{\varphi_0} \tag{6}$$

In terms of Hubble parameter $H=\frac{\dot{a}}{a}$, equation (6) takes the following form.

$$\left(\dot{H}+H^2\right)-H^2=\frac{dh}{dt}=-f\frac{\rho_0}{\varphi_0} \tag{7}$$

Integrating equation (7) and taking $H = H_0$ at $a = a_0 = 1$,

$$H = \frac{\dot{a}}{a} = f\frac{\rho_0}{\varphi_0}(t_0 - t) + H_0 \tag{8}$$

Integrating (8) and requiring that $a = a_0 = 1$ at $t = t_0$,

$$a = Exp\left[-\frac{1}{2}f\frac{\rho_0}{\varphi_0}(t^2 + {t_0}^2) + \left(f\frac{\rho_0}{\varphi_0}t_0 + H_0\right)t - H_0 t_0\right] \tag{9}$$

Using (9), the deceleration parameter $q = -\frac{\ddot{a}a}{\dot{a}^2}$ becomes

$$q = -1 + \frac{f\rho_0/\varphi_0}{\left(\frac{f\rho_0}{\varphi_0}(t_0 - t) + H_0\right)^2}. \tag{10}$$

Above equation clearly shows that a signature flip in $q$takes place at $t = \tau$where,

$$\tau = t_0 - \left(\sqrt{\frac{\varphi_0}{f\rho_0}} - H_0\frac{\varphi_0}{f\rho_0}\right) \tag{11}$$

According to other studies $< t_0$. For this condition to be satisfied we must have,

$$f > \frac{H_0^2\varphi_0}{\rho_0} = 28.7266 \tag{11a}$$

The values of different cosmological parameters used in this study are,

$H_0 = 72\left(\frac{km}{sec}\right) perMegaParsec = 2.33 \times 10^{-18}\ sec^{-1}$, $t_0 = 14\ billionyears = 4.415 \times 10^{17} sec$,

$\varphi_0 = \frac{1}{G} = 1.498 \times 10^{10} m^{-3} Kgs^2$, $\rho_0 = 2.831 \times 10^{-27}\ Kg/m^3$ (present density of dark matter + ordinary matter).

Let us now formulate the factor $f(t)$ from different criteria to be satisfied by it.

Based on (11a), we may take,

$$f(t) = \alpha\frac{H_0^2\varphi_0}{\rho_0} \text{ with, } \alpha > 1 \text{ at } at\ t = \tau = \beta t_0 \text{ with } \beta < 1 \tag{11b}$$

According to an initial assumption we have, $f(t) = 1\ at\ t = t_0$ (11c)

Let us now propose a linear relation between f and t which will satisfy the conditions expressed by (11b) and (11c). This relation is given by,

$$f = 1 + \left(\alpha\frac{H_0^2\varphi_0}{\rho_0} - 1\right)\frac{t_0 - t}{t_0 - \beta t_0} \tag{11d}$$

Now letting $q = q_0$ at $t = t_0$ in (10), one obtains $q_0 = -1 + \frac{\rho_0}{H_0^2\varphi_0}$

Its negative sign shows that the universe is presently passing through a state of accelerated expansion.

The scale factor has been plotted as a function of time in figure 1.

Figure 2has the plot of deceleration parameter as a function of time. It clearly shows that the

universe is presently in a state of accelerated expansion. It made a transition from an initial accelerated state to a decelerated state before attaining the present state of acceleration.

According to Brans-Dicke theory, the gravitational constant is the reciprocal of the scalar field parameter φ. Therefore, using equations (5) and (9) we have,

$$G = \frac{1}{\varphi} = \frac{a^3}{\varphi_0} = \frac{1}{\varphi_0} Exp\left[-\frac{3}{2}\frac{f\rho_0 t^2}{\varphi_0} + 3\left(H_0 + \frac{f\rho_0 t_0}{\varphi_0} \right) t - 3H_0 t_0 - \frac{3}{2}\frac{f\rho_0 t^2}{\varphi_0} \right] \quad (12)$$

and the fractional change of G per unit time is given by,

$$\frac{\dot{G}}{G} = 3\left[\frac{f\rho_0}{\varphi_0}(t_0 - t) + H_0 \right] \quad (13)$$

Equation (13) shows that, at the present time ($t = t_0$), $\frac{\dot{G}}{G} = 3H_0 = 2.2 \times 10^{-10} Yr^{-1}$

According to a study by Weinber, $\left(\frac{\dot{G}}{G}\right)_{t=t_0} \leq 4 \times 10^{-10} yr^{-1}$ [33]. Our result is consitent with this observation.

In the figures (3) and (4), we have plotted the time variation of G and $\frac{\dot{G}}{G}$ respectively. The gravitational constant is found to increase with time with a varying rate. Both curves show that the universe is presently passing through a stage where the rate of G variation is the smallest. This increasing nature of G has been found in some other studies [28, 29, 30, 32].

At $t = t_0$, $\frac{\dot{G}}{G}$ is positive, implying that the gravitational constant is presently increasing with time, The condition for having $\frac{\dot{G}}{G} > 0$ is

$$t < t_0 + \frac{H_0\varphi_0}{\rho_0} = 1.277 \times 10^{19} = 28.925\, t_0. \quad (14)$$

The gravitational constant will be decreasing with time and consequently $\frac{\dot{G}}{G}$ will be negative for $t \geq 28.925\ t_0$. It implies that beyond 28.925 times the present age of the universe, the gravitational constant will be decreasing with time. Using (2) and (5) we get,

$$\omega(\varphi) = -\frac{2}{3}\left(1 + \frac{\ddot{\varphi}\varphi}{\dot{\varphi}2} \right) = -\frac{2}{9}\left(7 - \frac{\ddot{a}a}{\dot{a}^2} \right) = -\frac{2}{9}(7 + q). \quad (15)$$

Equation (15) shows that the Brans-Dicke parameter $\omega(\varphi)$ has a linear relationship with the deceleration parameter (q).

At $t = t_0$ we have,

$$\omega(\varphi_0) = -\frac{2}{9}(7 + q_0) = -1.341 \quad (16)$$

Substituting for q in equation (15) from equation (10)

$$\omega(\varphi) = -\frac{2}{9}(7 + q) = -\frac{2}{9}\left[6 + \frac{f\rho_0/\varphi_0}{\left[\frac{f\rho_0}{\varphi_0}(t_0 - t) + H_0 \right]^2} \right]. \quad (17)$$

Equation (17) shows the time variation of Brans-Dicke parameter $\omega(\varphi)$.

Combining the equations (5) and (9) one gets,

$$\varphi=\varphi_0 a^{-3}=\varphi_0 Exp\left[-3\left(-\frac{1}{2}\frac{f\rho_0 t^2}{\varphi_0}+\left(H_0+\frac{f\rho_0 t_0}{\varphi_0}\right)t-H_0 t_0-\frac{1}{2}\frac{f\rho_0 {t_0}^2}{\varphi_0}\right)\right] \quad (18)$$

Figure (5) shows the variation of the Brans-Dicke parameter $\omega(\varphi)$ as a function of the scalar field φ and figure (6) shows its time dependence. It is found to be negative over the entire range of study.

We have plotted the deceleration parameter and the gravitational constant as functions of the scale factor (*a*), in the figures (7) and (8) respectively.

Conclusions

In the present study we have assumed an empirical dependence of the BD scalar field parameter φ on the scale factor (*a*). This model clearly shows that a generalized scalar tensor theory, where the BD parameter ω is regarded as a function of the scalar field φ, can drive an accelerated expansion for the present universe. Here we have found that the universe has made a transition from a decelerated phase of expansion to the present accelerated phase and it will continue to remain in the state of acceleration. This study also shows that there was accelerated expansion in the very early stage of the universe before the beginning of the deceleration phase. These calculations reveal that the gravitational constant increases with time. The rate of this increase is consistent with other studies in this regard. The present study shows the variation of the BD parameter $\omega(\varphi)$ graphically as a function of time and also the scalar field parameter φ. To take into account the exchange of energy between the field of matter (both dark and baryonic) and dark energy we have introduced a function *f*(*t*) in this model. It has been found to decrease with time indicating a slow conversion of matter into dark energy, which is considered to be responsible for this accelerated expansion of the universe.

FIGURES

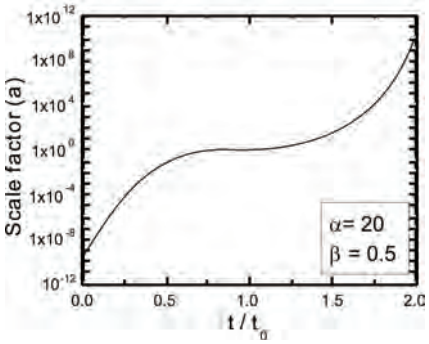

Fig 1
Variation of scale factor (*a*) as a function of time

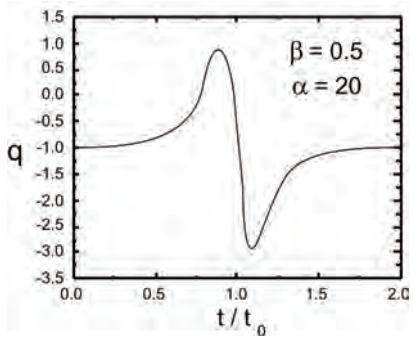

Fig 2
Variation of deceleration (q) parameter as a function of time

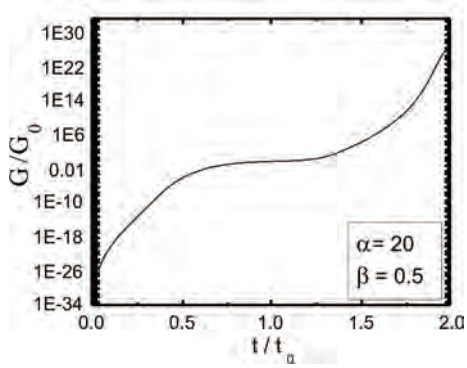

Fig 3
Variation of gravitational constant (G), as a function of time

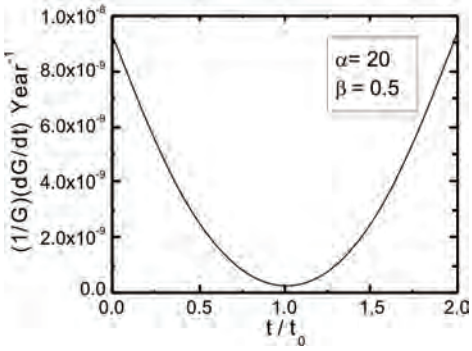

Fig 4
Variation of fractional change of *G* per second, as a function of time.

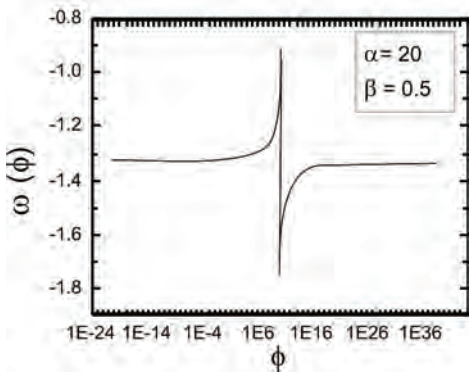

Fig 5
Variation of $\omega(\varphi)$ as a function of the scalar field φ

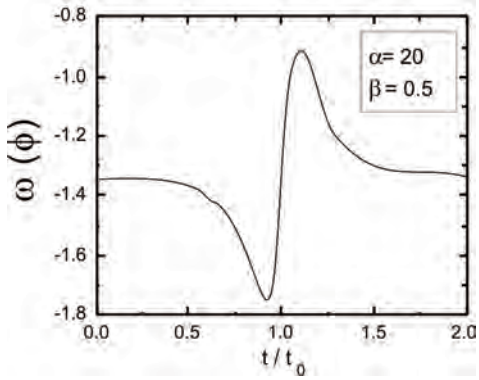

Fig 6
Variation of $\omega(\varphi)$ as a function of time

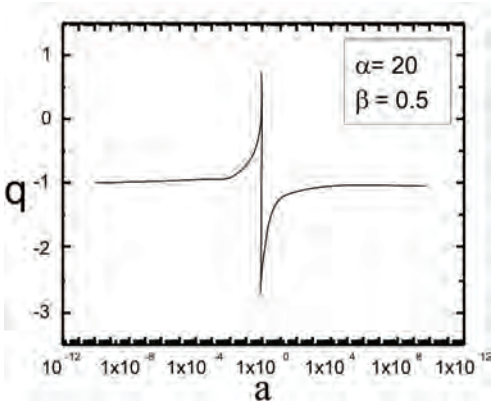

Fig 7
Variation of *q* as a function of the scalar field *a*

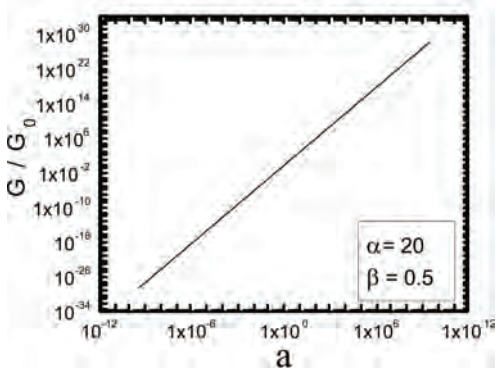

Fig 8
Variation of gravitational constant (G) as a function of the scale factor (*a*)

References

[1] S. Perlmutter et al, Astrophys.J., 483, 565 [1997], J. L. Tonry et al., Astrophys.J., 594, 1 [2003]

[2] A. G. Reiss et al., Astrophys.J., 607, 665 [2004]

[3] V. Sahni and A. A. Starobinsky, Int.J.Mod.Phys.D, 9, 373 [2000], T. Padmanabhan, Phys.Rept., 380,235 [2003]

[4] V. Sahni, Class.Quant.Grav., 19, 3435 [2002]

[5] J. C. Carvalho et al., Phys.Rev.D, 46, 2404 [1992], R. G. Vishwakarma, Class.Quantum.Grav., 19,4747 [2002]

[6] A. Sil and S. Som, Astrophys.Space.Sci., 115, 318 [2008]

[7] A .A. Sen and S. Sethi, Phys.Lett.B, 532, 159 [2002]

[8] N. Banerjee and S. Das, Gen.Relativ.Gravit., 37, 1695 [2005]

[9] T. Padmanabhan, Phys. Rev. D, 66, 021301 [2002]

[10] L. R. W. Abramo and F. Finelli, Phys. Lett. B, 575, 165 [2003]

[11] T. Chiba, T. Okabe and M. Yamaguchi, Phys. Rev. D,62, 023511 [2000]

[12] C. Armend´ariz-Pic´on, V. Mukhanov, and P. J. Steinhardt, Phys. Rev. Lett., 85, 4438 [2000]

[13] Gao, C., Chen, X. and Shen, Y.G., Phys. Rev.D, 79, 043511 [2009], arXiv:0712.1394 [astro-ph]

[14] S.del Campo, J.C. Fabris, R. Herrera, and W. Zimdahl, Phys. Rev. D, 83, 123006 [2001]

[15] W. Zimbdahl and D. Pawon, gr-qc/0311067, W. Zimbdahl and D. Pavon, astro-ph/040122

[16] S. Das, P.S. Corasaniti and J. Khoury, Phys.Rev. D. 73, 083509 [2006]

[17] N. Banerjee, S. Das and K. Ganguly, Pramana-Journal of Physics, 74, L481 [2010]

[18] O. Bertolami and P.J. Martins, Phys.rev.D, 61, 064007 [2000]

[19] A. Sheykhi, K. Karami, M. Jamil, E. Kazemi, M.Haddad, Int. J. Theor. Phys. 51, 1663 [2012]

[20] A. Sheykhi, K. Karami, M. Jamil, E. Kazemi, M. Haddad, Gen. relativ. Gravit. 44, 623 [2012]

[21] M. Jamil, I. Hussain, D. Momeni, Eur. Phys. J. Plus 126, 80 [2011]

[22] A. Pasqua, I. Khomenko, Int. J. Theor. Phys. 52, 3981 [2013]

[23] N. Banerjee and D. Pavon, Class.Quant.Grav., 18, 593 [2001]

[24] N. Banerjee and S. Das, Mod.Phys.Lett.A, 21 2663 [2006]

[25] S. Das and N. Banerjee, Gen.Relativ.Gravit, 38 785 [2006]

[26] T. Clifton and J. D. Barrow, Phys.Rev.D, 73 104022 [2006]

[27] N. Banerjee, K. Ganguly, Int. J. Mod. Phys. D, 18, 445 [2009]

[28] J.P. Singh, A. Pradhan, A. K. Singh, Astrophys. Space Sci., 314, 83 [2003]

[29] G. P. Singh, A. Y. Kale, Int. J. Theor. Phys. 48, 3158 [2009]

[30] A. Pradhan, B. Saha, V. Rikhvitsky, arXiv :1308.4842v1

[31] S. Ray, U. Mukhopadhyay, Dutta Choudhury, Int. J. Mod. Phys. D16, 1791 [2007]

[32] A. Pradhan, A. K. Singh, S. Otarod, Rom. J. Phys. 52, 445 [2007]

[33] Weinberg S, Gravitation and Cosmology : Principles ad Applications of the General Theory of Relativity, John Wiley & Sons, [1972]

Boremediation by Salt Tolerant *Brevibacillus* sp. as a cost-effective sollution for the Detergent Polluted Marine and Estuarine Zone

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Abstract

For decades, detergents are being used for washing and cleaning purposes. Inefficient wastewater and sewage treatment makes detergent pollution a major crisis of the 21st century. Many microorganisms like *Pseudomonas, Enterobacter, Bacillus, Shigella* etc. have been found to be effective in detergent degradation in consortia. Water samples from saline and polluted waters from Digha, West Bengal were taken and three bacterial strains B_1, B_2 and B_3 were isolated. The strains were tolerant to highly saline (upto 4% NaCl) and alkaline (pH 10) growth conditions, but were sensitive to antibiotics vancomycin, tetracycline and ciprofloxacin. The bacteria were found to degrade SDS, percentage degradation being highest for B_2 (92.2%) followed by B_3 (82.94%) and B_1 (75.45%). B_2 was also effective in degrading commercial detergents like Surf (35.5%), Sunlight (22.4%) and Ariel (8.2%) to some extent. Also, by performing the protein degradation assay, it was found that B_2 did not harm fish. This makes these isolates potential bioremediation agents to clean up detergents and preventing death of fishes by detergent toxicity. On doing a cost analysis it was found that bioremediation was far more cost effective than the conventional sewage treatment plants, since the only expenses are for the isolation and culturing process. Lastly, analysis of 16S rDNA sequence concluded that B_2 is *Brevibacillus borstelensis* strain NBRC 15714 (GenBank Accession Number: NR_113799.1).

Keywords: detergent pollution, SDS degradation, water treatment, bioremediation, cost effective, *Brevibacillus borstelensis*

Introduction

The fishery industry is one of the most important industries in the world, accounting to around Rs 90 billion annually in India alone. But recently this industry is being hampered

by deaths of large number of fishes due to water pollution by anthropogenic causes, one of the major pollutants being the detergents. 15 ppm of detergent can kill fishes, whereas concentrations as low as 5 ppm kills fish egg. Anionic surfactants can decrease surface tension which increases susceptibility of fishes and other aquatic fauna to other toxic pollutants like heavy metals, pesticides and phenols, giving rise to the problem of bioaccumulation and biomagnification (Olkowska et al., 2014). Fish exposed to detergent accumulate heavy metal and pesticide, which is toxic to humans on consumption (Chandanshive, 2014). Sodium dodecyl sulphate, $CH_3(CH_2)_{11}SO_4Na$, an anionic surfactant widely used in domestic and industrial expanses contributes greatly to this problem.

Conventional chemical wastewater treatment plants are not very efficient in detergent degradation (Usharani et al., 2012), and on top of that they are not cost effective. These treatment plants are very expensive to be constructed and their construction involves loss of natural ecosystem in that region, such that these plants cannot be set up everywhere. In India, it costs around Rs. 10,000 crores annually to treat sewage. Secondly, treatment plants cannot process all the sewage and a huge number of chemicals still find their way into the water bodies. Hence looking for alternative methods, which are both efficient and cost effective has become essential.

Previous studies have shown that microbial consortium of *Vibrio, Flavobacterium, Klebsiella, Pseudomonas, Enterobacter, Bacillus, Escherichia, Shigella, Citrobacter, Proteus* and *Anaebena* are effective in detergent degradation (Okpokwasili and Olisa, 1991). Also, *Brevibacillus*is a genus of Gram positive bacteria found in marine waters which have been found to be effective in polymer degradation. Bacteria thriving in marine environments are usually extremophilic and shows halophilic or halotolerant properties. This adaptation to extreme environment is possible due to the expression of unique genes which support life. Often these molecular variations lead to altered metabolism rendering these microbes capable of degrading many recalcitrant xenobiotic including detergents (Lewis et al., 1990). Hence, these extrememophiles can be used for the in situ bioremediation of polluted water bodies. Recently, in-situ bioremediation of water bodies is gaining popularity due to their easy technique and cost effectiveness.

The main purpose of this study was to isolate and characterize bacterial strains from the saline and detergent contaminated waters of Digha, west Bengal. These isolates were found to be efficient detergent degraders and hence can be used as an effective *in-situ* bioremediation technique for detergent removal in the marine and estuarine zone, thereby preventing fish death due to detergent toxicity.

MATERIALS AND METHODS

Collection of water sample

Water sample was collected from the Digha beach in East Midnapore district of West Bengal, India.

Physical characterization of watersample

Temperature, pH, electrical conductivity and dissolved oxygen were estimated using calibrated instruments. The salinity was calculated from dissolved oxygen value following equation Vernier kit.

Isolation of pure culture and maintenance of bacterial stocks

Different dilutions of water sample was spread on nutrient agar plates and incubated for 24-48 h at 37°C in a BOD incubator. Different colonies obtained were streaked on nutrient agar plates to obtain isolated single colonies, which were re-streaked to obtain pure culture. Tryptic soy broth (TSB) glycerol stocks of the cultures were maintained at -80°C for further experiments.

Colony, microscopic and biochemical characterization of bacterial isolates

Colony morphology of isolated pure cultures was noted, followed by Gram staining and microscopic examination. Catalase, oxidase, urease, nitrate reductase and IMViC tests were performed following standard protocol (Cappuccino and Sherman,2011).

Determination of salt and pH tolerance of bacterial isolates

Nutrient broth solutions containing 2%, 2.5%, 3%, 3.5% and 4% NaCl solutions were used to test for salt tolerance while pH values of nutrient broth adjusted to pH 8,10,12 were used to determine the pH tolerance. The readings were taken using a spectrophotometer at 600nm after 24 h for salt and pH. The growth curve for B_2 at pH 10 was also studied.

Antibiotic sensitivity test

Standard disc diffusion method was performed to determine antibiotic sensitivity using antibiotics vancomycin, tetracycline and ciprofloxacin (Cappuchino and Sherman, 2011).

Methylene blue active substance (MBAS) assay to determine sodium dodecyl sulfate (SDS) degradation in bacterial isolates

200μl of each of the bacterial isolate grown in nutrient broth was inoculated in SDS containing basal salt media (500 ml Basal salt medium contains- KH_2PO_4 3.5 g/l, K_2HPO_4 1.5 g/l, NH_4Cl 0.5 g/l, NaCl 0.5 g/l, Na_2SO_4 0.14 g/l, $MgCl_2.6H_2O$ 0.15 g/l and 1.5 mM SDS, pH of 7.1) and incubated at 37°C at 80 rpm shaking for 48 h. The SDS degrading capacity was determined by MBAS assay according to the method described by Jurado et al., 2006.

Protein degradation of fish by bacterial isolate B_2

1.5 g of fish samples were taken in sterilized petri plates for control and test. Fortest sample, fish was inoculated with 200μl of bacterial suspension B_2 only in first case and 200μl of bacterial suspension B_2 with 1% NaCl (w/v) in second case. The plates were kept in the incubator for 72 h. The samples were taken out, homogenized, centrifuged and the supernatant was collected. The protein quantification was done by Bradford assay (Quick Start™ Bradford Protein Assay Instruction Manual, BIO-RAD).

Identification of bacterial culture B_2 using *16SrDNA* based molecular techniques

16SrDNA was amplified by PCR using 8F and 1492R and single discrete PCR amplicon band at1500 bp was observed. Forward and Reverse DNA sequencing reaction of PCR amplicon was carried out with 704F and 907R primers using BDT v3.1 Cycle sequencing kit on ABI 3730xlGenetic Analyzer. Consensus sequence of 1452 bp 16SrDNA was generated from forward and reverse sequence data using aligner software. The 16SrDNA sequence was used to carry out BLAST alignment search tool of NCBI GenBank database. Based on maximum identity score first fifteen sequences were selected and aligned using multiple alignment software program ClustalW. Distance matrix was generated using RDP database and the phylogenetic tree was constructed using MEGA5 (Xcelaris Lab Ltd, Sample Id TSB-10).

Results

Physical characterization of water sample

The physical characteristics of water sample are summarized in Table 1. The sample had higher electrical conductivity (34.730 mS/cm) and salinity (24.45 psu) compared to distilled water. The pH (7.23) was near neutral.

Table 1 Physical Characterization of water sample

Test	Temperature	EC	DO	Salinity	pH
Control (dH_2O)	20°C	0.043mS/cm	5.9 mg/L	0.027 psu	6.84
Sample water	20°C	34.730mS/cm	6.9 mg/L	24.45 psu	7.23

Isolation and biochemical characterization of bacterial isolates:

Three pure cultures were isolated and selected from the water sample based on their colony morphology variations and designated as B_1, B_2 and B_3. Colony characteristics, morphology and Gram character is summarized in Table 2. Results of the biochemical tests have been tabulated in Table 3.

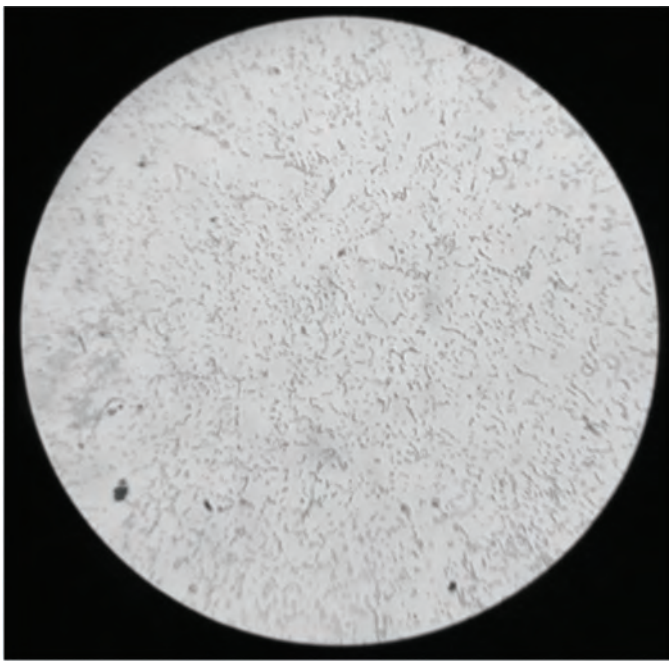


Fig 1. B_2 strain

Table 2

Characterization of bacterial isolates by gram staining, microscopic study and colony characterization

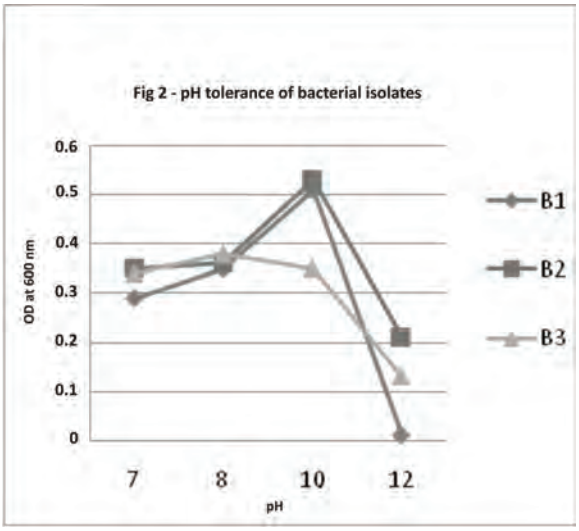
Bacterial isolates	Gram character	Morphology under 1000X magnification	Colony characterstics
B_1	Gram positive	Bacilli, occurring as diplobacilli and in clusters	Round, pin point, opaque, white with uneven edge and no elevation
B_2	Gram positive	Bacilli, occurring singly and in clusters	Round, pin point, translucent with round circular edge and moderate elevation
B_3	Gram positive	Bacilli, occurring as singly and in clusters	Round, yellowish with round circular edge and moderate elevation

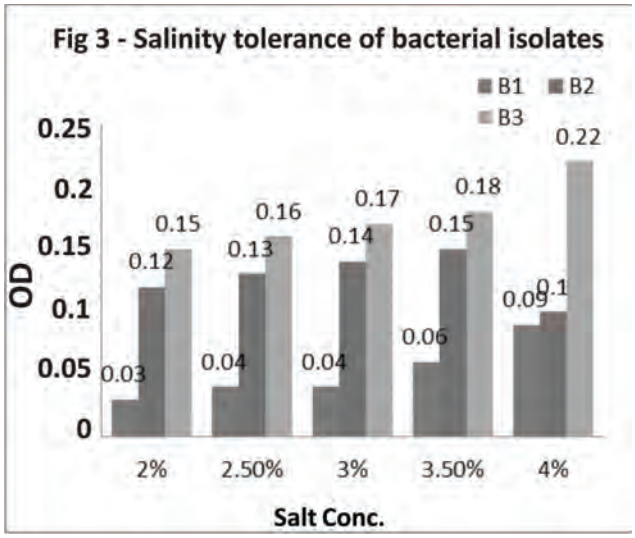
Table 3 Biochemical tests on bacterial isolates

Biochemical Test	B_1	B_2	B_3
Catalase	+	+	+
Oxidase	+	+	+
Nitrate Reductase	+	–	+
Indole	–	–	–
Methyl Red	+	–	+
Voges-Proskauer	+	+	–
Citrate	+	+	+
Urease	+	+	+

Determination of salt and pH tolerance of bacterial isolates

All the three bacterial species were found to grow at salt concentrations as high as 4%NaCl. B_3 was most salt tolerant followed by B_2 and B_1 (Fig 1). B_1 and B_2 had increased growth at pH 10 while at pH 12 bacterial growth was completely diminished (Fig 2).





Antibiotic sensitivity test

The zone of inhibition (ZOI) observed by disc diffusion assay showed that B_1, B_2 and B_3 was sensitive to common groups of antibiotics vancomycin, tetracycline and ciprofloxacin. The highest sensitivity of the strains was to ciprofloxacin with ZOI >3 in for all three bacterial isolates.

Table 1 Antibiotic sensitivity assay

Bacterial isolates	Diameter of zone of inhibition		
	Vancomycin	Tetracycline	Cliprofloxacin
B_1	2.8cm	3.4cm	3.6cm
B_2	2.5cm	2cm	3.2cm
B_1	2.6cm	1.8cm	3.4cm

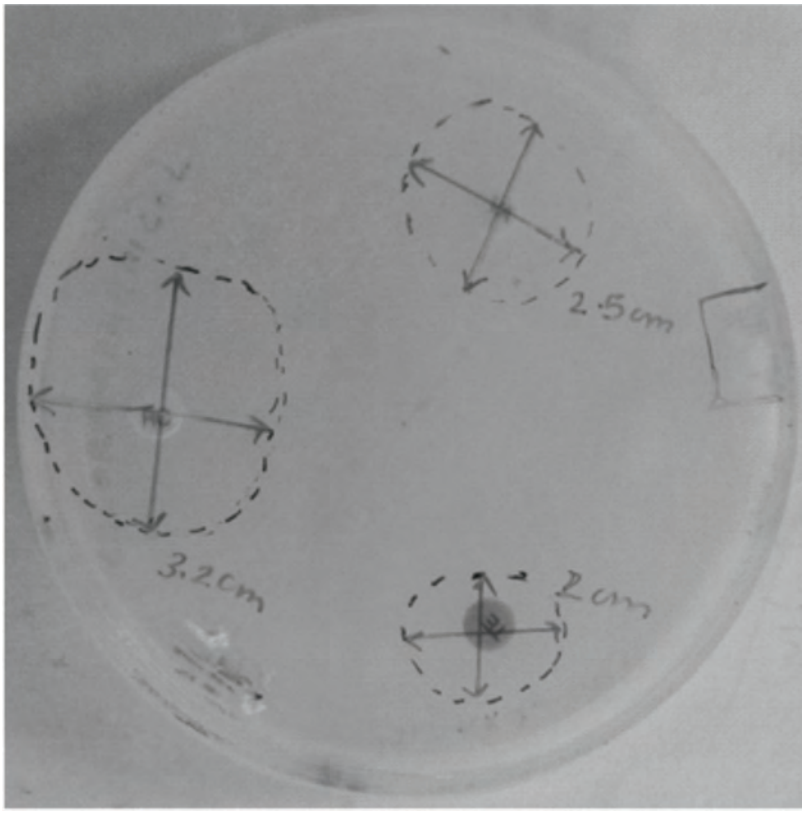
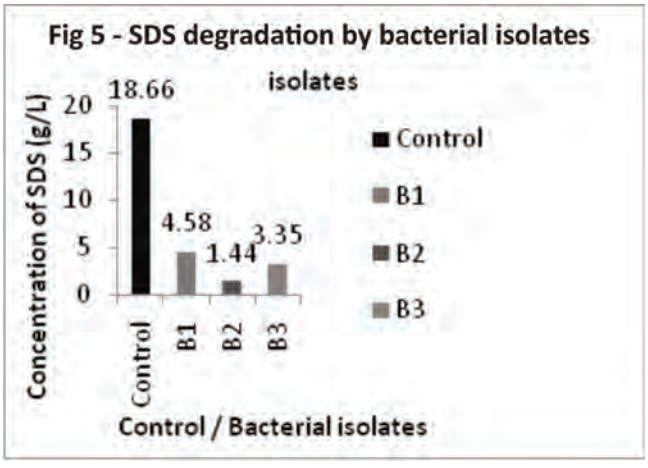
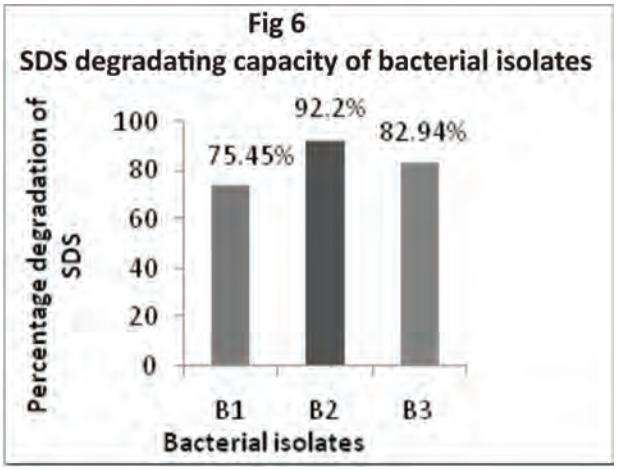


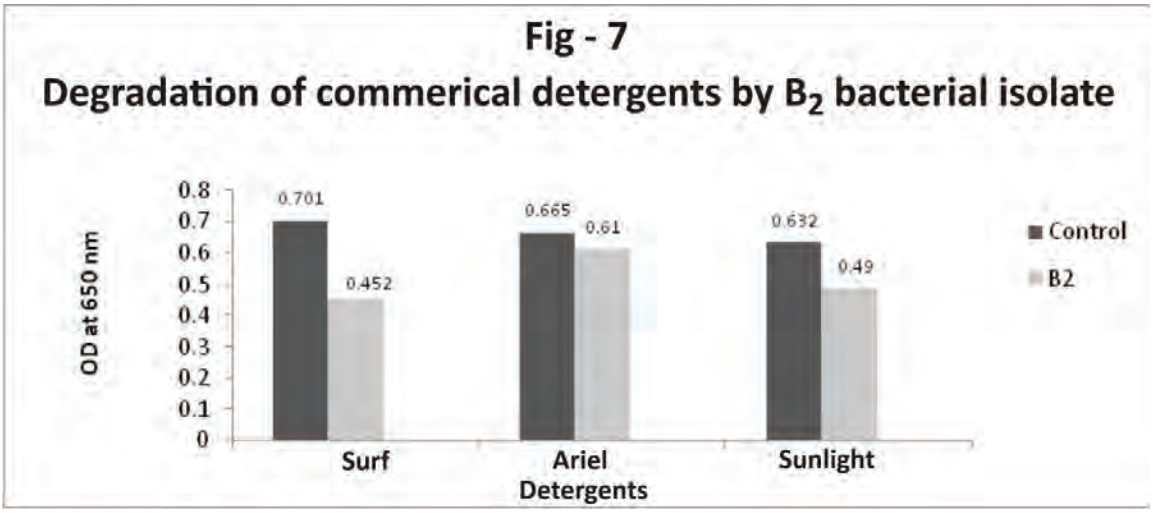
Fig 4. Antibiotic sensitivity of B_2

Methylene blue active substance (MBAS) assay to determine sodium dodecyl sulfate (SDS) degradation in bacterial isolates

The standard curve was plotted and the equation for the best fit graph was generated. The percentage degradation by each bacterial isolate was also plotted (Fig 5, Fig 6). B_2 was able to degrade 92.2% SDS, followed by B_3 (82.94%) and B1 (75.45%), showing a remarkable reduction in SDS content present in the basal salt media supplemented with SDS. After this B_2 isolate's ability to degrade commercial detergents like Surf, Ariel and Sunlight was also tested. The degradation of commercial detergents was not as noteworthy as SDS, but some reduction in detergent levels was definitely observed- 35.5% for Surf, 22.4% for Sunlight and 8.2% for Ariel (Fig 7).



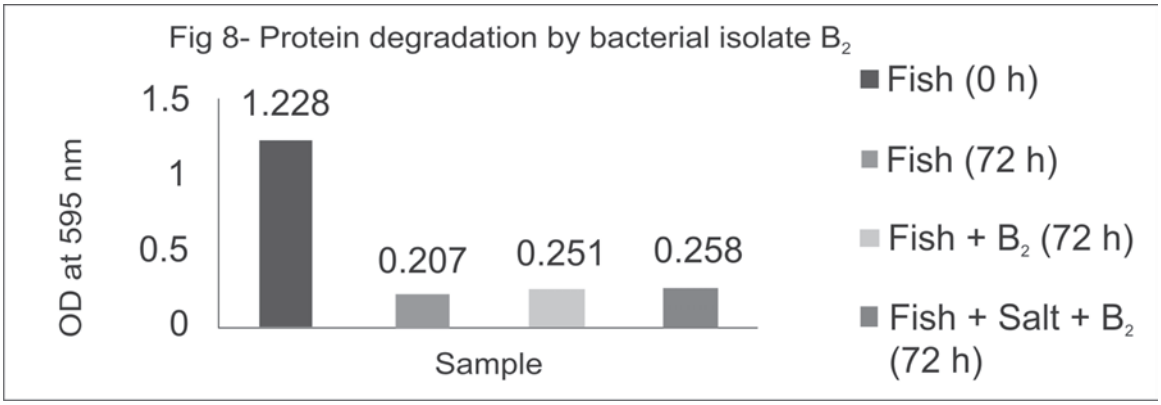




Protein degradation of fish by bacterial isolate B_2

After incubation, the protein degradation in the control fish sample (83.1%) from the initial protein estimated in fresh sample was same as the protein degradation in samples inoculated with bacteria B_2 (79.5%) and fish sample with salt and B_2 (78.9%)(Fig 8).

Identification of bacterial culture B_2 using 16SrDNA based molecular techniques



Bacterial isolate B_2 showed similarity with *Brevibacillus borstelensis* strain NBRC 15714 (GenBank Accession Number: NR_113799.1) based on nucleotide homology and phylogenetic analysis (Fig 8 and Fig 9)

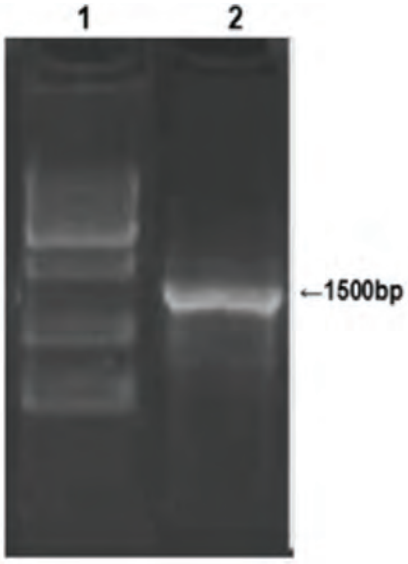


Fig 9.
1% Agarose get showing single 1.5 kb of 16SrDnA amplicon
Lane 1 - 1 kb DNA ladder
Lane2 - 16SrDNA amplicon
(Xcelaris Lab Ltd.)

Sequence Producing Significant Alignments

Accession	Description	Max score	Total score	Query coverage	E value	Max ident
AB712347.1	*Brevibacillus* sp. SI64	2669	2669	100%	0.0	99%
NR_113799.1	*Brevibacillus borstelensis* strain NBRC 15714	2669	2669	99%	0.0	99%
FJ982663.1	*Brevibacillus borstelensis* strain JBE0014	2669	2669	99%	0.0	99%
FJ529038.1	*Brevibacillus* sp. ES-SL-1	2669	2669	100%	0.0	99%
AF378230.1	*Brevibacillus borstelensis* strain LMG 15536	2669	2669	99%	0.0	99%
EU714902.1	*Brevibacillus borstelensis* strain SRDTh1	2667	2667	99%	0.0	99%
NR_040984.1	*Brevibacillus borstelensis* strain DSM 6347	2665	2665	100%	0.0	99%
AF252328.1	*Brevibacillus* sp. HC6	2665	2665	99%	0.0	99%
EU816694.1	*Brevibacillus borstelensis* clone K11	2663	2663	100%	0.0	99%
EU714903.1	*Brevibacillus borstelensis* strain SRDTh2	2663	2663	100%	0.0	99%
NR_041836.1	*Brevibacillus invocatus* strain LMG 18962	2453	2453	99%	0.0	97%
NR_125456.1	*Brevibacillus fulvus* strain K2814	2446	2446	99%	0.0	97%
EU730932.1	*Brevibacillus invocatus* strain 176	2446	2446	98%	0.0	97%
KF626524.1	*Brevibacillus panacihumi* strain NAM2	2444	2444	97%	0.0	98%
KF555360.1	Bacterium KB37	2442	2442	98%	0.0	97%

Phylogenetic Tree:

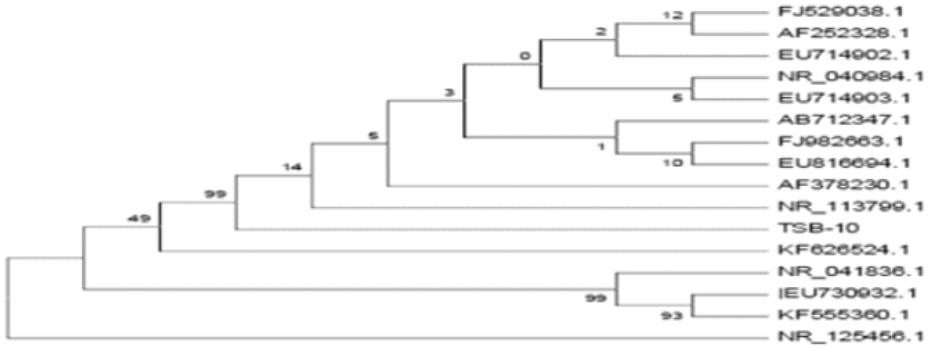


Fig 10. Identification of the bacteria

Discussion

The three bacterial isolates collected from the detergent polluted waters of Digha, West Bengal, were Gram positive bacilli with tolerance to pH as high as 10 and salt concentration of 3.5% NaCl. Being isolated from natural sources all the bacterial strains were found to be sensitive to commonly used antibiotics vancomycin, tetracycline and ciprofloxacin. Ciprofloxacin being a broad spectrum antibiotic was most effective with ZOI >3 for all three strains. This suggested that the isolates were mostly non-pathogenic and can be easily controlled. Study of SDS degradation revealed that bacterial strain B_2 had high SDS degradation ability of 92.2%, followed by B_3 (82.94%) and B1 (75.45%). The B_2 SDS degradation values being so high, it was further tested for degradation of commercial detergents, Surf (35.5%), Sunlight (22.4%) and Ariel (8.2%). This observation does indicate that B_2 in consortium with other detergent degrading bacteria can degrade commercial detergents and can be used in water treatment and sewage treatment effectively. B_2 was also found to not harm fish and can be assumed that increased concentration of B_2 in detergent polluted natural water bodies can be used for bioremediation purposes. By sequencing and BLAST alignment of *16SrDNA* sequence B2 was found to be *Brevibacillus borstelensis*strain NBRC 15714 (GenBank Accession Number: NR_113799.1). Previous studies have shown that extromophilic *Brevibacillus* sp. are present in deep sea vents and hence, aquatic environments. Strains of *Brevibacillus* isolated from hotsprings near Konkan, Maharashtra have been found to possess bile salt degrading enzymes. The present studies also reveal that *Brevibacillus borstelensis* is capable of degrading SDS and to some extent commercial detergents.

The ability of this isolate to degrade detergent and tolerate such extreme conditions where the normal microbes cannot survive gives them great potential to act as *in-situ* bioremediation agents in the estuarine and marine zone, which is the home of large number of fish species and marine organisms. They can also be used to treat the hyper-saline effluents from the tanneries, where most of the bioremediation bacteria cannot grow due to high salt concentrations. *In-situ* bioremediation is also very cost effective compared to *ex-situ* bioremediation and conventional water treatment plants. There is only an initial investment in terms of isolation and maintenance of the cultures in the laboratory and some monthly and yearly monitoring of the region to assess the effectiveness of the technique. Also, once the isolates are released into the natural environment, they will self-propagate, given their higher efficiency to survive in the marine waters.

The cost comparison of the 2 remediation technique can be shown by the following table:-

Approximate cost	Operational Cost (Power cost + Man power0 (per annum)	Construction Cost
Water treatment plant	Rs 3500000	Rs 3000000-Rs10000000 (per MLD)
In-situ Bioremediation	Rs 1000000	Rs700000 (for 1000 square feet)

(All the figures given above are a rough estimate. Source: CPCB)

In conclusion, it can be said that *Brevibacillus borstelensis*, tolerant to high pH and saline conditions, was very successful in degrading SDS and could to some extent also degrade commonly used commercial detergents. *Brevibacillus borstelensis* in conjunction with other detergent degrading bacteria can be used as potential candidate for biodegradation of detergent and addressing the problem of detergent pollution. Further research to isolate and purify the enzyme(s) responsible for degradation and further investigation of the performance of *Brevibacillus borstelensis* in microbial consortia with other bacterial species known to degrade detergents and surfactants, and their implementation in water treatment can have a great impact in providing a very cost effective and efficient way of controlling and subsiding detergent pollution.

Acknowledgement

We would sincerely like to thank our respected principal, Rev. Dr. J. Felix Raj S.J. and the H.O.D. Department of Microbiology, St. Xavier's college for their support.

References

[1] Brown, V. M.,Mitrovic, V.V., Stark, G.T.C., *Effects of chronic exposure to zinc on toxicity of a mixture of detergent and zinc*, Water Research. 1968; 2: 255-263.

[2] Chandanshive, E, N.,*Effects of Different Concentrations of Detergents on Dissolved Oxygen Consumption in fresh water fish Mystusmontanus*, International Research Journal of Environmental Sciences. 2014; 3(8): 2319:1414.

[3] Chaturvedi, V., Kumar, A., *Isolation of a strain of Pseudomonas putida capable of metabolizing anionic detergent sodium dodecyl sulfate (SDS)*, Iranian Journal of Microbiology. 2011; 3: 47-53.

[4] Goodnow, Robert A., Harrison, Jr. Arthur P., *Bacterial Degradation of Detergent Compounds*, American Society for Microbiology. 1972; 24: 555-560.

[5] Jurado, E., Fernandez-Serrano,M.,Nunez-Olea,J., Luzon,G.,Lechuga, M., *Simplified spectrophotometric method using methylene blue for determining anionic surfactants: Applications to the study of primary biodegradation in aerobic screening tests*, Chemosphere. 2006; 65: 278-285.

[6] Olkowska, E., Ruman, M., Polkowska, Z., *Occurence of Surface Active Agents in the Environment*, Journal of Analytical Methods in Chemistry. 2014;

[7] Orcutt, N. Beth., Sylvan, B. Jason., Knab, J. Nina., Edwards, J.Katrina., *Microbial Ecology of the Dark Ocean, at, and below the Seafloor*, American Society for Microbiology. 2011; 75: 361-422.

[8] Quick Start™ Bradford Protein Assay Instruction Manual, BIO-RAD

[9] Shahbazi, R., Kasra-Kermanshahi, R.,Gharavi S., Moosavi- Nejad, Z., Borzooee, F., *Screening of SDS-degrading bacteria from car wash wastewater and study of the alkylsulfatase enzyme activity*, Iranian journal of Microbiology. 2013; 5: 153-158

[10] Usharani, J., Rajasekar, T., Deivasigamani, B., *Isolation and Characterization of SDS (Sodium Dodecyl Sulphate) Degrading Organisms from SDS Contaminated Areas*, Open Access Scientific Reports. 2012; 1:1-148.

Gender Inequality In India : A Constraint to Economic Development

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Abstract

The gender gaps in economic activities, women's poverty and their social exclusion are mainly due to gender-specific constraints and inequalities.Social norms may be considered here as powerful factors in determining the allocation of productive–reproductive tasks and status rather than rational considerations of equality, capability and efficiency.The perpetuation of gender inequality in economic activities generates practices of assigning lower positions to women in firms and factories. Women are usually engaged in low-skilled, informal work condition and earn less than men for similar work. These gender gaps are worsened by the non-accountability of their household work and domestic care. Domestic violence or its threat within the household may be seen not only as an economic or social problem but also a form of labour extraction.

Present study unveils many faces of gender inequalities which are in fact detrimental to economic development of India in the present globalized hypercompetitive markets.

Keywords: Gender inequality, Women empowerment, Sex ratio, Competitive advantage, Gendergap

1. Introduction

Men and Women are the twin architects of the human civilization. But, historically women have been depriving from their rights and privileges throughout the world. They are always been confined to household activities. However, in the present globalized hypercompetitive markets where human resources happen to be the prime factor towards maintaining or achieving competitive economic advantages, there would no rationale to unutilize or underutilize nearly half of the economy's potential human resources. Again, there is no reason to consider women human resources as less potential than that of men. In fact, in practice, women are not given opportunities or rather deprived from revealing their potentiality. Evidences showed that promoting women's access to resources and their control over incomes would help boost economicgrowth.As a result,women's access to economic resources has now been considered as important factor of economic growth as well as

ensuring the gender equity of growth outcomes. It implies that women's empowerment and economic growth are mutually reinforcing each other. Thus, women's economic empowerment appears to has direct link with labour market through which women gain access to economic resources.

In spite of the fact that during last few decades women's participation in economic activities has been significantly increasing in India but they are continuously facing challenges in pursuing better payment, productive jobs and in accumulating assets. Social attitudes towards gender roles are passed from generation to generation and such cultural transmission has implications for women's pressure in the labour market. For women, the effect of these attitudes results in limited opportunities in the labour market (Farre and Villa, 2013).

Strong empirical support is virtually claiming that gender equality has a positive impact on economic growth. Over the last few decades this relationship is most consistently found across different countries with regard to education and employment. All these macro findings supported that women's access to employment and education opportunities reduce the likelihood of household poverty and also revealed that resources in women's hands have a range of positive outcomes for human capital and capabilities within the household (Quisumbing, 2003; WDR 2012; Kabeer, 2003; Dwyer and Bruce, 1988). Such findings become the strong rationale for ensuring women's participation in the processes of growth and it will contribute to the inclusiveness of growth. It is not merely because women constitute almost half of the world's population, but alsobecause women's access to economic resources improves distributional dynamics within the household. Inclusive growth ensures opportunities for all sections of the population, with a special emphasis on the poor, particularly women and young people, who are most likely to be marginalized.

However, gender inequality is not one homogenous phenomenon, but a collection of disparate and inter-linked problems. Present paper tries to focus on a few of the disparity between the genders which is one of the major impediments to economic development.

2. Diversified Nature of Gender Inequality

Gender inequality in India is very complex and diversified, because it is present in many ways, many fields and many classes. According to the United Nations Development Program's Human Development Report 2013, India ranks 132 out of 187 countries on the gender inequality index – lower than Pakistan (123). Fields like education, employment opportunities, where men are always preferred over women.Disparities between the genders in some of the key areas are discussed below.

2.1 Gender Inequality in the Sex Ratio

The sex ratio in India has been historically unfavourable to females. In 1901, the sex ratio of India was 972 and since then the sex ratio has continuously been sharply declining and reached 945 in 1941. In the post independent period, the sex ratio in India stood at 927 in 1991, lowest in 110 years. From 1991 there has been an increasing trend and in 2011 the sex ratio in India becomes 940.While comparing 2001 and 2011 censuses, it appears that among the major states, Jammu & Kashmir, Bihar and Gujarat have experienced a fall in the sex ratio. Perceptible increase has been observed in the major states, such as Uttar Pradesh, Rajasthan, Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, Andhra Pradesh, West Bengal, Maharashtra, Kerala, Tamil Nadu, Punjab and all North-Eastern states. In this regard Kerala (1084), Tamil Nadu (995), Andhra Pradesh (992) and Chhattisgarh (991) have recorded the highest sex ratio (see table 1). A point to be noted is that the states having historically low sex

ratio(such as Punjab, Haryana, Delhi) have shown appreciable increase in the sex ratio in 2011.

Sex ratio of child population in the age group 0-6 indicates a continued trend of preference of male children over females. This indicates that although government has banned doctors from revealing the sex of the unborn child, female infanticide is still very common in India. Therefore, despite the laws to prevent female feticide and schemes to encourage families to have girl child (e.g. *Kayanshree* in West Bengal), the child sex ratio has fallen in 2011.

Table 1

Sex Ratio of Total Population and Child Population in Age group of 0-6 and 7+ years : 2001-2011

State	Sex ratio (femals per 1,000 males)					
	Total population		Child population in the age group 0-6		Population age 7 and above	
	2001	2011	2001	2011	2001	2011
Jammu & Kashmir	892	883	941	859	884	887
Himachal Pradesh	968	974	896	906	980	983
Punbab	876	893	789	846	888	899
Uttarkhand	962	963	908	886	973	975
Haryana	861	877	819	830	869	885
Delhi	821	866	868	866	813	866
Rajasthan	921	926	909	883	923	935
Uttar Pradesh	989	908	916	899	894	910
Bihar	919	916	942	933	914	912
Assam	935	954	965	957	929	953
West Bengal	934	947	960	950	929	946
Jharkhand	941	947	965	943	935	948
Orissa	972	378	953	934	976	985
Chhattisgarh	989	991	975	964	992	995
Madhya Pradesh	919	930	932	91	916	933
Gujarat	920	918	883	886	927	923
Maharashtra	922	925	913	883	924	931
Andhra Pradesh	978	992	961	943	981	997
Karnataka	965	968	946	943	968	971
Goa	961	968	938	920	964	973
Kerala	1059	1084	960	959	1072	1099
Tamil Nadu	987	995	942	946	993	1000
India	**933**	**940**	**927**	**914**	**934**	**944**

Source : Census of India 2011 provisional population totals, paper 1 of 2011, India series 1

2.2 Gender Inequality in Literacy Rate

Literacy is one of the prime factors for women empowerment. At the national level, the male-female literacy gap in the 2001 census stood at 21.59 where as in the 2011 census it is only 16.68. The decadal difference in literacy rate for males and females stands at 6.88 and 11.79 percentage points respectively. It indicates a substantial improvement in respect of female literacy. In the census 2001, in 11 states the male-female literacy gap was higher than the national average and in the remaining 18 states it was below the national average level.But, in census 2011, in 10 states the male-female literacy gap is higher and in the remaining 19 states it is below the national average (see table 2).

Table 2

Literacy rate and decadal difference in literacy rates by sex : 2001-2011

State	2001			2011			Decadal difference in literacy rates	
	Male	Female	Gender Gap	Male	Female	Gender Gap	Male	Female
Jammu & Kashmir	66.60	43.00	23.60	78.26	58.01	20.25	11.66	15.01
Himachal Pradesh	85.35	67.42	17.93	90.83	76.30	14.23	548	9.18
Punjab	75.23	63.36	11.87	81.48	71.34	10.14	6.25	7.98
Uttarakhand	83.25	59.63	23.65	88.33	70.70	17.63	5.05	11.07
Haryana	78.49	55.73	22.76	85.38	66.77	18.61	6.89	11.04
Delhi	87.33	74.71	12.62	91.03	80.93	10.10	3.70	6.22
Rajasthan	75.70	43.85	31.85	80.51	52.66	27.85	4.81	8.81
Uttar Pradesh	68.82	42.22	26.60	79.24	59.26	19.98	10.42	17.04
Bihar	59.68	33.12	26.56	73.39	53.33	20.06	13.71	20.21
Assam	71.28	54.61	16.67	78.81	67.27	11.54	7.53	12.66
West Bengal	77.02	59.61	17.41	82.67	71.16	11.51	5.65	11.55
Jharkhand	67.30	38.87	28.43	78.45	56.21	22.24	11.15	17.34
Orissa	75.35	50.51	24.84	82.40	64.36	18.04	7.05	13.85
Chhattisgarh	77.38	51.85	25.53	81.45	60.59	20.86	4.07	8.74
Madhya Pradesh	76.06	50.29	25.77	80.53	60.02	20.51	4.47	9.73
Gujarat	79.66	57.80	21.86	87.23	70.73	16.50	7.57	12.93
Maharashtra	85.97	67.03	18.94	89.82	75.48	14.34	3.85	8.45
Andhra Pradesh	70.32	50.43	19.89	75.56	59.74	15.82	5.24	9.31
Karnataka	76.10	56.87	19.23	82.85	68.13	14.72	6.75	11.26
Goa	88.42	75.37	13.05	92.81	81.84	10.97	4.39	6.47
Kerala	94.24	87.72	6.52	96.02	91.98	4.04	1.78	4.26
Tamil Nadu	82.42	64.43	17.99	86.81	73.86	12.95	4.39	9.43
India	**75.26**	**53.67**	**21.59**	**82.14**	**65.46**	**16.68**	**6.88**	**11.79**

Source : Census of India 2011 provisional population totals, paper 1 of 2011, India series 1

Table 3

Literacy rate among persons of age 5 years and above for different social groups

Socal Group	Rural			Urban			Rural + Urban		
	Male	Female	Person	Male	Female	Person	Male	Female	Person
ST	701	526	615	880	720	804	717	554	631
SC	721	523	623	831	691	764	743	555	654
OBC	780	575	679	886	753	822	808	621	716
Others	842	685	767	935	860	900	879	757	821
All	773	585	682	900	789	848	811	640	728

Source : NSS 66th round (July 2009-June 2010), Key Indicators of Employment and Unemployment in India, CSO, NSSO, Government of India, June 2011, NSS KI (66/10).

As regard the male-female literacy rate differentials, while in all the cases male literacy is higher, the differential varies across social groups. Thus, for rural India, whereas the all-social group differential is about 18.8 percentage points, corresponding group specific differentials are 20.5 (OBC), 19.8 (SC), 17.5 (ST), and 15.7 (Others) percentage points. For urban India these differentials are about 11.1 (all social groups), 14 (SC), 16 (ST), 13.3 (OBC) and 7.5 (Others) percentage points respectively (see table3).

2.3 Gender Inequality in Labour Participation Rate

It is well recognized that promoting women's control over their incomes and resources would help boost economic development. However, in practice the women's economic security is worsened by ongoing policies and existing institutional set ups. Women's economic insecurity appears as one of themajor forms of gender inequality in labour participation rates across the Indian states.

Table 4

Labour Force Participation Rate (LFPR), Worker Population Ratio (WPR), Proportion Unmployed (PU) for persons of age 15-59 years acording to usual status (ps+ss) in some of the major states

State	Rural						Urban					
	Male			Female			Male			Female		
	LFPR	WPR	PU	LFPR	WPR	PU	LFPR	WPR	PU	LFPR	WPR	PU
Punjab	825	800	26	349	340	8	836	799	37	185	173	13
Haryana	798	779	17	381	379	5	819	801	18	208	202	7
Rajasthan	821	815	6	566	565	0	772	758	13	193	184	9
Uttar Pradesh	842	830	11	282	282	1	777	754	23	118	114	4
Bihar	828	809	18	106	105	1	751	703	47	91	77	14
Assam	872	841	33	256	241	14	806	772	33	149	129	18
West Bengal	883	867	16	223	216	7	853	823	31	209	195	14
Jharkhand	841	799	42	264	261	3	767	726	42	155	136	20

State	Rural						Urban					
	Male			Female			Male			Female		
	LFPR	WPR	PU	LFPR	WPR	PU	LFPR	WPR	PU	LFPR	WPR	PU
Orissa	892	862	30	372	362	10	835	799	36	178	169	10
Madhya Pradesh	872	864	8	445	443	2	762	741	21	194	187	7
Gujarat	898	890	8	477	474	3	844	831	13	213	207	7
Maharashtra	836	829	6	560	558	2	824	799	23	235	223	13
Andhra Pradesh	846	834	10	628	621	6	807	787	20	267	252	15
Karnataka	897	891	6	527	524	2	825	805	20	251	241	10
Kerala	836	805	30	367	302	65	801	775	26	345	284	61
Tamil Nadu	859	844	15	560	550	9	838	817	22	283	267	16
India	**848**	**834**	**15**	**898**	**391**	**7**	**809**	**785**	**23**	**210**	**198**	**12**

Source : NSS 66th round (July 2009-June 2010), Employment and Unemployment Situation among Social Groups in India, Government of India, September 2012, Report No. 543 (66/10/3).

Labour force refers to the population which supplies or seeks to supply labour for production of goods and services and therefore includes both the 'employed' and 'unemployed'. The labour force participation rate (LFPR) is the number of persons in the labour force per 1000 persons.In the age group 15-59 years, in the usual status (ps+ss), LFPR at the all-India level is about 85 per cent for rural male and about 40 per cent for rural female. The corresponding figures are about 81 per cent for urban male and 21 per cent for urban female. Male-female differences in LFPR are seen to be quite prominent not only at the all-India level but also almost all the states (see table-4).

The number of persons employed per 1000 population is referred to worker population ratio (WPR). The WPR for persons of age 15-59 years in the usual status (ps +ss) depicts a clear picture of significant gender differences. At the all-India level WPR for rural male is the highest (83 per cent) followed by urban male (79 per cent), rural female (39 per cent) and it is the lowest for urban female (20 per cent). Gender differentials in WPR for all the states are appears to be quite alarming (see table-4).

Proportion Unemployed (PU) is defined as the number of persons/person-days unemployed per 1000 persons/person-days. PU among the persons of age 15-59 years in the usual status (ps +ss) is not very significant for both male and female at the all India level. Both in rural and urban areas female PU is just half of male PU (see table-4).

2.4 Gender Inequality in Wages

The wage structure in the informal sector of India has continued to remain gendered where women are receiving lower wages than men. In India, minimum wages are set for different types of employment within a state and across states, but these are differentially implemented for women and men. It is evident from the report of the National Commission for Enterprisesin the Unorganized Sector (NCEUS) that 85 per cent of casual workers in rural areas and 57 per cent ofcasual workers in urban areas are paid wages that are below the minimum wages (NCEUS, 2007).

It also appears from NSS 66th round (2009-10) that significant male-female wage differentialcontinued to exist in all the states both in rural and urban sectors (activity status code: 31, 71, 72 and 51). At the all-India level the average rural wage differential (Rs. 93.28)

is greater than that of urban (Rs. 68.37). The highest rural male-female wage differentialsare observed (in activity status code: 31, 71, 72)in the state of Assam (Rs. 153.31), Rajasthan (Rs. 148.56), Orissa (Rs.142.15), Maharashtra (Rs. 129.25), Punjab (Rs. 126.20), Jharkhand (Rs. 109.01) and Andhra Pradesh (Rs. 104.47). On the other hand, maximum urban male-female wage differentials are observed in the state of Jharkhand (Rs. 276.44), Kerala (Rs.130.15), Karnataka (Rs.121.58), Orissa (Rs. 120.41), West Bengal (Rs. 114.69) and Assam (Rs. 110.27). It is interesting to note that both in rural and urban sectors of Bihar and in the urban sector of Punjab and Haryana average per day female wage is higher than that of male (see table-5). Significant male-female wage differentials are also observed in the all-India annual average daily wage rates in agricultural and non-agricultural occupations in rural India during the year 2010-2011 (see table-6).

Table 5

Average wage/salary earnings (in Rs.) per day received by regular wage/salary employees (activity status code : 31, 71, 72 and 51) of age 15-59 years for the major states

State	Rural				Urban			
	Activity status code				Activity status code			
	31,71,72		51		31,71,72		51	
	Male	Female	Male	Female	Male	Female	Male	Female
Punjab	263.01	136.72	133.46	91.80	342.35	374.49	142.65	85.68
Haryana	299.11	202.04	146.08	99.12	316.91	330.10	154.27	70.58
Rajasthan	261.55	12.99	132.29	94.31	374.42	317.85	146.04	100.04
Uttar Pradesh	235.60	148.11	97.04	69.21	360.29	285.54	109.30	72.37
Bihar	252.59	371.76	81.03	65.81	338.31	500.75	94.04	59.63
Assam	248.31	95.00	94.38	74.87	491.19	380.92	115.65	82.01
West Bengal	180.21	97.29	87.76	65.94	391.77	277.08	98.98	78.41
Jharkhand	272.67	163.57	103.61	82.17	491.94	215.50	108.53	74.41
Orissa	293.87	151.72	81.00	59.06	358.89	238.48	100.26	72.80
Madhya Pradesh	154.03	138.15	74.46	58.13	325.15	230.33	88.92	75.48
Gujarat	187.02	178.08	87.31	70.99	306.58	221.35	119.02	66.32
Maharashtra	293.76	164.51	86.01	58.22	439.30	391.71	121.55	57.64
Andhra Pradesh	198.31	93.84	115.41	75.71	341.63	248.05	155.20	92.85
Karnataka	195.08	112.60	96.91	62.77	414.95	293.37	123.03	67.88
Kerala	290.79	213.29	226.60	119.31	450.76	320.61	237.42	120.90
Tamil Nadu	256.49	161.47	132.14	72.62	319.60	277.23	155.40	76.19
India	**249.15**	**155.87**	**101.53**	**68.94**	**377.16**	**308.79**	**131.92**	**76.73**

Source : NSS 66th round (July 2009-June 2010), Key Indicators of Employment and Unemployment in India, CSO, NSSO, Government of India, June 2011, NSS KI (66/10).

Note : code 31 = worked as regular wage/salaried employee; code 71 = did not work owing to sickness but had regular salaried/wage employment; code 72 = did not work owing to other reasons but had regular salaried/wage employment; coe 51 = worked as casual wage labour in other than MGNREG public works.

Table 6

All-India Annual Average Daily Wage rates in Agricultural and Non-Agricultural Occupations in Rural India during the year 2010-2011

Wage rates (in Rupeess) in Agricultural Occupations			Wage rates (in Rupees) in Non-Agricultural Occupations		
Occupation	**Male**	**Female**	**Occupation**	**Male**	**Female**
Ploughing	145.51	87.23	Carpenter	194.98	-
Sowing	125.75	98.17	Blacksmith	147.16	-
Weeding	111.22	95.79	Cobbler	104.50	-
Transplanation	120.19	104.17	Mason	213.57	@
Harvesting	122.53	102.36			
Winnowing	112.83	94.83	Tractor driver	151.90	-
Threshing	117.78	97.08			
Picking	121.10	101.19	Sweeper	85.21	85.99
Herdsman	77.17	60.43			
Well-digging	170.32	93.81	Unskilled	122.85	93.56
Cane crushing	120.33	89.09	Labourers		

Source : Wage rates in rural India (2010-2011), Govt. of India, Ministry of Labour & Employment, Labour Bureau, 2012

Note : * = Picking includes picking of cotton bolls/seed pods, jute stalks and tea leaves etc.

- = Not reported; @ = Number of quotations are less than five.

2.5 Gender Inequality in Ownership of Assets

Gender disparities in ownership and control of land and other productive assets becomes a major concern of the development planners and policy makers of India. While preparing India's Twelfth Five Year Plan, the Planning Commission had made a series of policy consultation meetings with civil society groups, including the Feminist Economist Group organized. They came up with a general conclusion that the measures for joint titles have not worked and they remained inconsequential for the social and economic empowerment of women. As a consequence of the policy consultation meetings, it is clearly stated in the current Twelfth Five Year Plan of India 2012-2017 that: 'where new land is being distributed or regularized, individual titles in women's name only, rather than joint titles with husbands could be considered. States may also want to consider group titles to women's groups … and recognize such groups as valid category of land owners'. In cases where joint titles were issued in the past to occupants of government land, 'such pattas would be made partition-able so that wives if they so desire, can have half the share of land in their single names.'

Although, gender budget initiatives have been piloted in India but no evaluative exercise of the gender differentiated impact of public expenditures has been carried out. As a poverty reduction strategy as well as freeing women from their large-scale engagement in low-skilled, low-paid jobs, the Microfinance for the poor women is launched. To increase women's income earning abilities, this Microfinance project encourages women's self-employment and enterprise development and for that they are providing training in undertaking small and medium-scale businesses.

3. Concluding Remarks

It is surprising that in spite of so many laws, women are still continued to live under stress and strain. In India, women's deprivation has been continued to persist in all social and economic activities.But, in the present globalized competitive markets human resource plays a decisive role to maintain or to achieve competitive advantage and in this regard women constitute half of the total human resources of an economy. Therefore, India needs to deactivate the gender Inequality. The needs of the day are trends where girls are able not only to break out of the culturally determined patterns of employment but also to offer advice about career possibilities that look beyond the traditional list of jobs. To ensure equality of status for women we still have miles to go.

Reference

Dwyer, D. & J. Bruce (eds) (1988). A home divided: women and income in the Third World, Stanford University Press.

Farre, L. & Vella, F. (2013). The intergenerational transmission of gender role attitudes and its implications for female labour force participation, *Economica*, 80, 219–47.

Kabeer, N. (2003). Mainstreaming gender in poverty eradication and the Millennium Development Goals. London: Commonwealth Secretariat/IDRC Publication.

National Commission for Enterprises in the Unorganized Sector (NCEUS) (2007).Report on conditions of work and promotion of livelihoods in the unorganized sector, New Delhi, Academic Foundation.

Quisumbing, A. (2003). Household decisions, gender and development. A synthesis of recent research Washington: IFPRI.

World Bank (2012).World Development Report, 2012. Gender equality and Development, Washington: World Bank.

Antimicrobial Activity of a unique Polyvinyl Chloride Degrading Mould from Municipal Wastes

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Abstract

The adverse effects of plastic products on the environment are overwhelming. Bioremediation is an effective, safe and inexpensive method which can be employed for in-vitro biodegradation of plastic. In this study, the exceptional ability of a mould, isolated from municipal wastes, to degrade the Polyvinyl chloride (PVC- a component of plastic), has been described. Also, the fungus exhibited its ability to inhibit the growth of bacteria. Cultural and microscopic characterisation revealed that the isolated fungus was an *Aspergillus* sp. The effectiveness of this particular mould for the degradation of PVC films were studied for one month under laboratory conditions. After one month, final weight of PVC strips was measured. For experimental set up one, 35.38% and for experimental set up two, 29.53% weight loss of the PVC strips were observed. This suggested that the mould was capable of utilizing PVC as a source of carbon for its growth under suitable condition. To confirm the antimicrobial properties of the extracellular substance produced by the mould it was first extracted and the crude extract was then assayed for its antibacterial property via agar cup-plate method. For gram positive bacteria (*Bacillus subtilis*) the diameter of zone of inhibition obtained was 2 cm whereas the diameter of zone of inhibition obtained for gram negative bacteria (*Pseudomonas aeruginosa*) was 2.5 cm. Hence, it is concluded that the isolated fungal strain can be used for plastic degradation under optimized condition in-vitro and it is also able to produce some extracellular substance with broad spectrum antimicrobial activity.

Keywords: Bioremediation, Biodegradation, Polyvinyl chloride

Introduction

Plastic initially was introduced for human welfare. It came with some excellent features such as great durability, low maintenance, light weight etc. which made it a ubiquitous component, utilized almost everywhere. Its redeeming ecological features came to light

when plastic products started to get accumulated in the environment due to overproduction and their unchecked utilization.[1] They affect the environment by imposing adverse effects on wildlife, aquatic life as well as on humans. The prominence of plastic pollution is not only due to their abundance in nature but also because of their very slow biodegradability.[2] Bioremediation is an effective, safe, low-cost & non-invasive method which can be used as a control measure for hazardous effects of plastic. Bioremediation makes use of microbes that possess an extraordinary ability to utilize a wide variety of substrates and can convert toxic substrates to their nontoxic eco-friendly forms.[3] The indiscriminate use of plastic products by the public is increasingly becoming an environmental issue in India. Public places and municipal dumping grounds are continuously being littered with these recalcitrant materials in large amounts.[1] Therefore it is high time to look for some unique and efficient microbes that can bring about rapid biodegradation of these materials. This present study was aimed to isolate some novel fungi from municipal dump yard containing bulk of plastic wastes.

MATERIALS AND METHODS

Isolation and characterisation of heterotrophic fungi from plastic wastes

Plastic wastes (polythene bags, cups etc.) were separated from the whole municipal waste and washed with sterile water. Then PDA plates supplemented with ambystrin were prepared for the serial dilution agar plate method. The water obtained after washing the plastic wastes were serially diluted from 10^{-1} to 10^{-5} and pour plated in the prepared PDA plates. The plates were incubated for 4-5 days at 30°C temperature. Colony characterization of the mould obtained in PDA plates was then carried out. It was found that only 10^{-2} and 10^{-3} dilution plates showed growth and the colonies obtained from these plates had similar morphology and appearance. Microscopic observation was also carried out which confirmed the presence of same mould.The dimensions of fungal isolate were measured with the help of micrometry.

Microbial degradation of PVC films

Three pre-weighed UV sterilised alcohol washed PVC strips were taken and aseptically transferred to three petridishes. One strip was for control set up and the other two were for experimental set up. In experimental set up one a fungal colony of diameter 1.55 cm was placed on PVC film having initial weight 0.195gm and in experimental set up two fungal colony of diameter 1.6 cm was placed on PVC film with initial weight 0.149gm. Control was maintained in a microbe free environment. The plates were incubated for 30 days at 30°C. 2ml of sterile dH_2O was added to each petridish at every two days of interval to keep the chambers moist. After one month, the PVC strips were collected, washed thoroughly using distilled water, shade-dried and weighed for final weight. From the data collected, weight loss of the PVC strips was calculated.

Determination of antimicrobial activity of the isolated fungus

To check if the isolated mould had any additional unique property of inhibiting bacterial growth, a colony of the mould was placed onto the lawn of bacterial cultures i.e. both gram positive (*Bacillus subtilis*) and Gram-negative (*Pseudomonas aeruginosa*)organism. The plates were then incubated at 37°C for 24hrs. The zone of inhibition was observed in the NA plates which gave an indication about the antimicrobial activity of the isolated fungus.

Crude extraction of antimicrobial substance from the isolated fungus

As it could be realised from the above experiment that the isolated mould had antimicrobial activity hence lays the need of extracting the antimicrobial substance from the fungus in crude form. For this, the fungal mycelia was taken and grown in PDB. The broth is filtered. The filtrate containing the crude product was further purified using chloroform solvent twice for 2 days for better phase separation of the presumable antimicrobial substance followed by evaporation of chloroform and the crude extract was then dissolved in absolute ethanol.

Assay of Antimicrobial Activity of Extracted Material

The crude antimicrobial substance extracted from the mould was further assayed for its activity. For this, 100μl of standard Gram-positive (*Bacillus subtilis)* and gram-negative bacteria (*Pseudomonas aeruginosa)*were taken and spread on NA plates. Two agar cups were cut off from each plate-one well was kept as control having 100μl of 100% ethanol and another containing the test antimicrobial crude extract of exact volume. The plates were then incubated at 37°C for 24hrs and the inhibition zones were observed thereby proving the efficiency of the crude extract.

Results

Mould isolated from the plastic wastes was identified as *Aspergillus* sp (Fig.1).

Table 1 Dimensions of the fungal isolate

Organism	Ocular Reading	Final Reading (ocular reading ×CF um)	Average (um)
Fungus			
Sporangiophore Length	74	74 × 3.3 = 244.20	254.10
	82	82 × 3.3 = 270.60	
	75	75 × 3.3 = 247.50	
Sporangium Diameter	11	11 × 3.3 = 36.30	39.60
	13	13 × 3.3 = 42.90	
	12	12 × 3.3 = 39.60	
Spore Diameter	02	02 × 3.3 = 6.60	06.60
	02	02 × 3.3 = 6.60	
	02	02 × 3.3 = 6.60	

Table 2 Determination of weight loss of PVC films after treatment with the fungal isolate

System	Duration (days)	Diameter of Fungal Colony (cm)	PVC Initial Weight (gm)	PVC Final Weight (gm)	Difference of weight (gm)	% of Degradation
Control	30	--	0.154	0.154	0.000	0.000
Experimental Set up 1	30	1.55	0.195	0.126	0.069	35.38
Experimental Set up 2	30	1.60	0.149	0.105	0.044	29.53

After one month, the final weight of the PVC strip in control set up was same as that of the initial weight. For experimental set up one (Fig.2), 35.38% and for experimental set up two (Fig.2), 29.53% weight loss was observed.

Table 3

Determination of diameter of the zone of inhibition produced by the fungal isolate

Organism	Gram Character	Zone of Inhibition	Diameter of the zone of Inhibition (cm)	Average (um)
Bacillus subtilis	Gram-positive	+	1.6	1.60
			1.7	
			1.5	
Pseudomonas aeruginosa	Gram-negative	+	2.03	2.03
			2.03	
			2.03	

The diameter of zone of clearance, produced by the mould when directly placed in gram positive (*Bacillus subtilis*) bacterial lawn, was 1.6 cm whereas the zone diameter was 2.03 cm for gram negative bacteria (*Pseudomonas aeruginosa*) (Fig.3).

Table 4

Determination of diameter of the zone of inhibition produced by the crude extrace of antimicrobial substance from the fungal isolate

Organism	Gram Character	Zone of Inhibition for control	Zone of Inhibition for anti-microbial Test substance	Diameter of Inhibition Zone (cm)	Average Diameter (cm)
Bacillus subtilis	+	—	+	2.0	
				2.0	2.0
				2.0	
Pseudomonas aeruginosa	—	—	+	2.5	
				2.5	2.5
				2.5	

The crude extract of the extracellular antimicrobial substance obtained from the mould also produced zone of inhibition of diameter 2 cm and 2.5 cm (Fig.4) for the above specified gram positive and gram negative bacteria respectively.

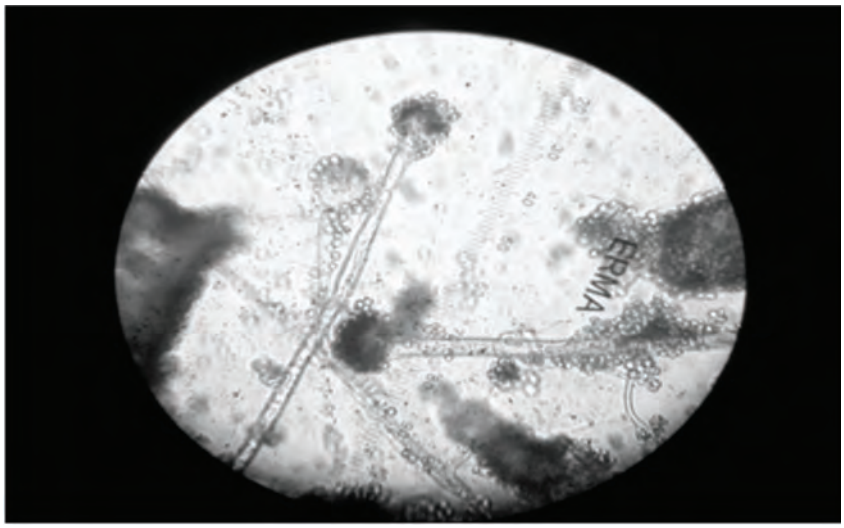

Fig 1. Microscopic observation (40x) of isolated *Aspergillus* sp.

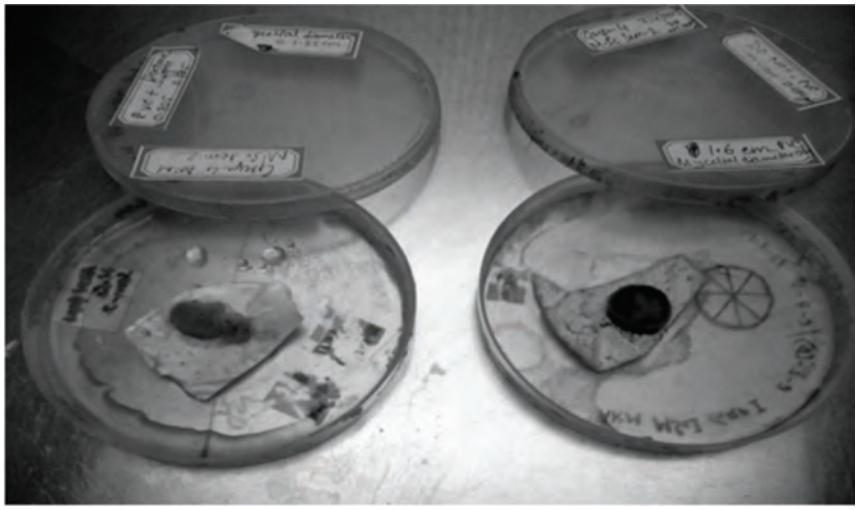

Fig 2. Experimental set up 1 showing the fungal growth on PVC (30 days)

Fig 3. Dried PVC film after degradation

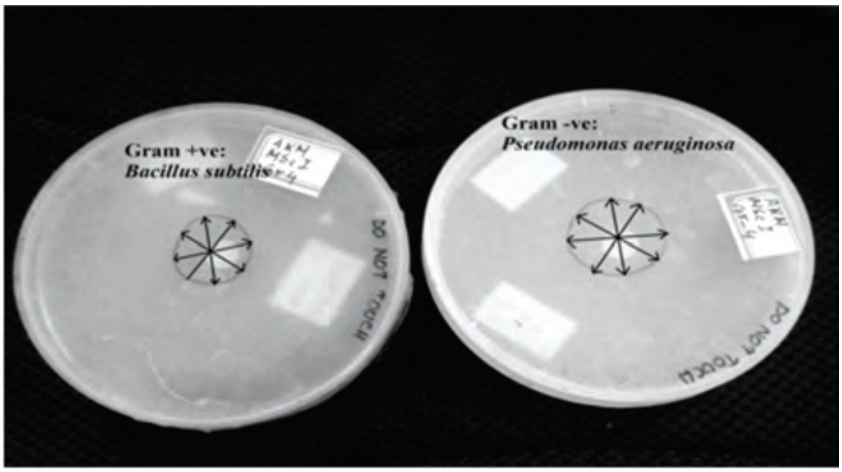

Fig 4. Zone of inhibition after 24 hours of incubation around the fungal colony

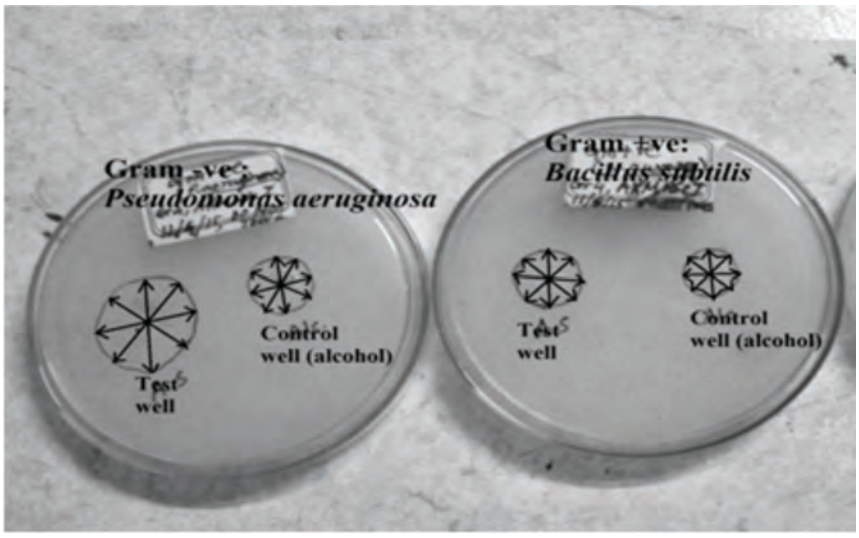

Fig 5. Assay of Crude extract of extracellular antimicrobial substance obtained from the mould. (Marked area around test wells indicates zones of inhibition for both Gram positive and Gram negative bacteria.)

Discussion

Microorganisms play a significant role in biological decomposition of materials, including synthetic polymers in natural environments.[1] The present study provides evidence that a novel microbe was successfully isolated from the municipal wastes that had the exceptional ability to degrade Polyvinyl Chloride (PVC) which is the major constituent of plastic.[4] It could be proved by finding the percentage of degradation of PVC strips by the isolated mould within a very short span of time under laboratory conditions which was identified to be *Aspergillus* sp. The mould could utilize PVC as the source of carbon for its growth. This can be a valuable finding for solving the problem of biodegradation of plastic wastes around the world *i.e.* for bioremediation purposes and can easily help to reduce the harmful effects of plastic pollution caused due to the plastic waste disposal around land sites, rivers along with marine bodies. Moreover, the isolated fungus had the immense ability to inhibit the growth of gram-positive as well as gram-negative bacteria by producing the extracellular antimicrobial substance through the formation of inhibition zones around them thereby inferring the toxic nature of this extracellular substance possessing a broad spectrum of antimicrobial activity.

Conclusion

We could conclude that we isolated a unique mould from municipal waste having an exceptional feature to degrade synthetic polymer such as PVC. The rapid degradation of PVC films in-vitro in laboratory condition with the isolated *Aspergillus* sp. suggested that this particular mould had efficiently utilised vinyl chloride as a sole source of carbon for its survival and growth. Therefore, this mould can be employed effectively for the bioremediation of plastic wastes. The mould has an additional feature of producing extracellular antimicrobial substance with broad spectrum of activity. Hence, this mould has got various economic aspects which are yet to be applied for nature and human welfare.

Acknowledgement

We would like to thank our respected Principal Rev. Dr. J. Felix Raj S.J., H.O.D and the entire department of Microbiology for their immense support.

References

[1] Raaman N, Rajitha N, Jayshree A, et al. Biodegradation of plastic by *Aspergillus* spp. isolated frompolythene polluted sites around Chennai. J Acad Indus Res 2012; 1(6):313-316.

[2] Sivasankari S, Vinotha T. In Vitro Degradation of Plastics (Plastic Cup) Using *Micrococcus luteus and MasionellaSp* .SchAcad J Biosci 2014; 2(2): 85-89.

[3] Dey U, Mondal NK, Das K, et al. An approach to polymer degradation through microbes. IOSR-JPBS 2012; 2(3):385-388.

[4] Patil R, Bagde US. Isolation of polyvinyl chloride degrading bacterial strains from environmental samples using enrichment culture technique. Afr J Biotechnol 2012; 11(31):7947-7956.

Revising Environmental Sanitation in Colonial Bengal— An Analytical Discourse Based on the Cholera and Plague Epidemics (1900-1930)

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A Public Health in Colonial Bengal- the Beginning

This paper seeks to explore the history of cholera and plague epidemics in colonial Bengal from 1900 – 1930 where the need for environmental sanitation played an important role. During the British rule in Bengal, the initiatives for environmental sanitation i.e. for clean water, pure air and conservancy were rare. Perhaps two reasons were responsible for this. Firstly, the government had a tendency to avoid such matters which could provoke native hostility as they often raised voice against reforms. Secondly, the authorities always gave priority to their own men regarding the conservation of health, hygiene and sanitation.

According to the colonisers, Bengal was probably the dirtiest place on earth in the beginning of the British rule. In 1837, James Ronald Martin wrote, -

"Whoever has visited the native portion of the town before sun-rise, with its narrow lanes and "rankest compound of villainous smells that ever offended nostril", will require no argument, in favour of widening the streets...It must be confessed, the natives have yet to learn in a public and private sense, that the "sweet sensations connected with cleanly habits and pure air, are some of the most precious gifts of civilization..."[1]

The colonial concern for public health was superficial. This particular situation started to transform from 1880s as certain measures were taken for decentralisation of health administration. But unfortunately, no drastic change took place as the colonial masters lacked sympathy for the natives. In the 10th Annual Report of the Sanitary Commissioner for Bengal (1877), the Commissioner lamented, -

''In considering the influence of atmospheric changes on sickness and mortality it must be remembered that in this Province many sources of diseases are always present, such as soil infiltrated with excrement, and water contaminated with sewage, while the population is poor and ignorant, badly housed, clothed and fed – and displays a painful apathy towards sanitary improvements. It is hard to eliminate these adverse factors..."[2]

This colonial mentality tried to set in a trend of apathy which was later followed by other officials as the documents exhibited. There were discrepancies to a great extent as the primary objectives of the Sanitary Commission,which was established in 1868, were never been implemented with an honest zeal.

For example, in the beginning of the year 1868, the Sanitary Commissioners were appointed for Bengal, Punjab, North-Western Provinces, Central Provinces, Oudh and British Burmah. In the month of August of the same year an official report was published on the subject of *'progress made in sanitation in India'*.In this particular report, certain recommendations were made under the headings of *"want of money', weakness and inefficiency of municipalities; ground conditions and necessity for engineering surveys and drainage; water –supply; chemical analysis meteorology; conservancy; cholera enquiry, &c."*[3]

More importantly, several officials made applications to the Government for the establishment of *'a library of special reference on sanitary science'*[4].The *Raj* sanctioned a special grant of Rs. 2000 for buying such works and Messrs. Churchill & Sons sold their books on public health, conservancy, drainage and others to the Government of India.[5]

But all these led to reform the sanitary condition of the military cantonments only. As in an official Minute of 1866, the Government of India clearly mentioned that the *Raj* would only spent money for the betterment of sanitation in the military cantonments, the rest was on the shoulders of the local authorities depended on local funds.[6]

The officials like Ronald Ross through his writings repeatedly mentioned the need for proper drainage and conservancy which was overlooked by the government. The fear of tropical climate as it was the birthplace of many ailments, opened new avenues for medical research with special emphasis on germ theory.

In 1884, J.M. Cunningham wrote a book on *'Cholera: What can the State do to prevent it?'* Here he remarked –

"*The so-called sanitary measures which have been adopted by most of the continental nations of Europe and also by America are based on certain theories. Whether these theories are scientifically correct or not is a matter of very minor importance. It is true they are negative by all the great facts in the history of Cholera both in India and in other countries, but the mainquestion with which I wish to deal is, not* whether *they are true or false, but whether the action taken on them has been of the smallest benefit to mankind"*[7]

The above-mentioned author like Ross had a genuine concern for the natives which was perhaps one of the important features of colonial medical literature of late 19th and early 20th centuries.

B The Threats of Cholera and Plague- Revisiting Colonial Health

1 Cholera

(a) *The Early Years* (1817 -1900)

In 1868, from the Report of the Sanitary Commissioner, we come to know that *'Cholera appeared in an epidemic form for the first time in the Dacca District in July 1817…The epidemic was more fatal in the mofussil villages, than in the city…At the beginning the disease was most fatal; and males were liable to attacks in a double proportion to females.'*[8]

Perhaps this was the first official document which mentioned about cholera and the history of cholera epidemic in Bengal before 1817 was not known to the colonisers.

Initially, the government had no specific agenda to treat the native victims of the above-mentioned ailment. The same report stated,*'Between 1817 and 1830, no accommodation was provided for in-patients in the native hospital. This prevents our ascertaining the rate of mortality of the disease at the period.'*[9]Between 1830 to 38, and 40 to 49, cholera took a severe form which in 1851 was "*destroying hundreds in the city*".[10]

Up to 1860, the colonial government failed to produce any complete record on the mortality rate from Cholera as the data and statistics were mainly collected from jails, military cantonments, lunatic asylums and the hospitals. The Native and Mitford Hospitals of Bengal chiefly served the Europeans and perhaps no specific data was kept for the native patients.

It was also a period which witnessed colonial efforts to investigate the reasons behind the disease. The Sanitary Commissioner for Bengal wrote in his report, *'Cholera is most prevalent, at those seasons, when there is the greatest range of temperature, as in April and November, and there appears to be a close connection between the attacks and exposure to chills, especially at night.'*[11]

During the second half of the 19th century, cholera became a serious threat in all over India and also in the neighbouring countries. Sanitary Commissioner for Madras, Surgeon W.R.Cornish wrote in 1870, -

'It will be... necessary in this place to recognize the fact that cholera does move in accordance with its own laws, and that a new epidemic movement in the Bengal Provinces is...sure to be felt...not only in the tract of country to the north-west of Bengal, but also to the extreme south-east of Asia, including Burmah, the Straits Settlements, and China, and to the extreme south of the Madras Presidency...' [12]

S.C. Townsend, the Sanitary Commissioner for the Central Provinces, published a *'Memorandum on the precautions to be taken against Cholera'*. In this Memorandum, he gave sixteen suggestions to prevent cholera and emphasised on the fact that, *'The great object of all sanitary precautions is to prevent, if possible, those unwholesome conditions which favour the spread of Cholera...'*[13]

In the beginning, the colonial rulers of Bengal had sympathy for their own men and this particular mentality started to transform from 1880s. This particular period witnessed the creation of the post of Deputy Sanitary Commissioner and gave clear indication towards decentralization of health administration.

In 1895, the government passed Pilgrims Act to prevent cholera which was surely a land mark in this direction.[14] There was no doubt in the fact that the Hindu pilgrims in India and the Muslims who went for *Haz*and also returned from there – were the main culprits regarding the spread of the ailment. In Bengal, the fairs like *ShibChutturdossi*(Serampoer), *Kuri* (Malda), and*Agradip* (Burdwan) became the depots of cholera as mentioned by John Martin Coates, the Sanitary Commissioner for Bengal in 1878.[15] He further wrote, -

'At the Sib Chutturdossi a native doctor was employed, other than that no necessary sanitary arrangements were taken. After fasting the whole day, the victims took the bad food, as a result of which this disease was caused. To state the cause of this ailment, stagnant and polluted water ranks first. Besides the insanitary state of air, soil, food, drainage, conservancy and crowing were noted in addition.'[16]

The colonial government adopted certain measures of quarantine to protect the mass as the religious gatherings were very common both for Hindus and Muslims.

The colonial masters gradually realised the importance of environmental sanitation, especially of water purification to prevent cholera. In 1889, the then Sanitary Commissioner, Major W.H. Gregg in an official letter wrote about *'...impure drinking water and its close connection with cholera'*[17] and ordered all the municipalities to adopt schemes on water purification.[18]

(b) *The Colonialand Native Initiatives for Water Purification: The Beginning of Environmental Sanitation to Eradicate Cholera* (1900-1930)

The official concern for safe potable water supply took a definite shape in the beginning of 20th century. In the Thirty-Third Annual Report for the Sanitary Commissioner (1900), Major Dyson gave a satisfactory statement on disinfection of wells. He stated,

'During the year under review disinfection of wells with Permanganate of Potash was carried on during cholera epidemics in 25 districts (Birbhum, Midnapore, Hooghly, Jessore, Chittagong etc.) against 14 districts in 1899. This was freely done in the districts of Dinajpore, Rangpur, Champaran and Bhagalpur...As a precautionary measure all wells were disinfected twice a year, once during Doljatra and then during Rathayatra...'[19]

Apart from these above-mentioned efforts, the colonial masters also started anti-cholera inoculation movement and made the natives in-charge of this. For example, Gopal Chandra Mukherjee, the Assistant Surgeon was appointed as the in-charge in 1900.[20]

In 1928, the District Health Officer of Faridpur, Dr.Abhoy Kumar Sarkar wrote a book in Bengali where he described the duties and responsibilities of the District and Union Boards to prevent cholera.

He also wrote about the orthodox villagers who often resisted any kind of reform movement. On the other hand, the inefficiency of the indigenous health workers was another reason which made the situation more critical.

Sarkar had a view that, the Government had a genuine concern and wanted to spend money for environmental sanitation and prevention of cholera. But the natives were reluctant and showed non-cooperation.[21]

Sarkar's opinion was definitely an important one to judge the situation. On the other, in numerous official reports, the Sanitary Commissioners and others repeatedly admitted about financial crunch which gave many projects on water supply and sanitation an abrupt end.

For example, Major H.J. Dyson, the Sanitary Commissioner for Bengal once commented, *'only ten municipalities...spent over 10 percent of their income on original sanitary works...It should, I think, be made a standing rule that not less than 5 percent of municipal income should be spent every year on original sanitary works. If this were done, drainage, water supply and conservancy arrangements would very soon improve.'*[22]

The natives of Bengal also came forward to save the land from cholera. The vernacular medical journal, *SwasthyaSamachar*in 1925 gave a description of native initiatives to prevent cholera. It was mentioned,

'When there is an outbreak of cholera, the volunteers of 'Cholera Brigade' of the 'KendriyaSamiti' and 'BangiyaSwasthyaSamiti' help the victims by providing aids. They use to distribute bleaching powder, lizol, potassium permanganate to every house, nurse the affected people, take attempts to keep the ponds clean and secure pure water supply, and make the villagers aware about the evil effects of cholera by giving lectures. They performed well in Ganga SagarMela.'[23]

Perhaps the educated natives were more concern than the government for environmental sanitation and also to eradicate the above-mentioned ailment.

In 1930, Dr.JnanMaitra wrote a book on '*Practical Cholera Treatment (On Homeopathic Principle)'* in Bengali. According to him, there was no difference between the Summer Cholera of England, and the Cholera of India, popularly known as Asiatic Cholera as termed by C. Macnamara in his book, '*Asiatic Cholera'* (1876).[24]

Maitra further pointed out that, there were certain differences such as '*metorological, climatic, condition of prosperity, habits of life'* between the two countries which perhaps became responsible for the epidemiological dissimilarities. But this did not prove the fact that cholera migrated from India to England.He cited H.W. Bellew, who stated, -

'For whilst in England as well as in India, it is the poorer classes of the people who mostly suffer from the ravages of the disease; it is also a fact the appearance of severe or unusual epidemic prevalence of cholera in England is quite independent of the prevalence of the disease in India...' [25]

From the beginning of the 20th century, the natives through their writings tried to set in a specific trend of awareness. They wrote many articles on cholera and the methods to prevent it. These people did not have any idea on environmental sanitation. But they successfully traced the connection between insanitation and the outbreak of cholera. Even they criticised the government for their cultivated indifference. This particular mentality was previously absent. In 1919, *SwasthyaSamachar* wrote,

'One of the most important tasks of our municipality is to provide safe and pure drinking water. The municipal authorities should look at this matter not only in the big cities, but also in the small villages...If anybody attempts to pollute the water of well or ponds the authorities should prevent it by appointing chowkidars...Though it is money consuming but it will definitely help to eradicate cholera...'[26]

2 Plague in Bengal - An Era of Colonial Apathy and the Plight of Poor Natives

From an official report, namely, *'Observations on Plague in Eastern Bengal and Assam'*, we come to know that, in Bengal before the advent of British, plague was never endemic. The records of Bubonic Plague were few and perhaps this ailment was imported from outside. It was written,

'*We may conclude therefore that plague infection has been frequently brought into the province and that there are definite reasons for the disease not becoming endemic.'*[27]

Plague in Bengal took a definite shape from 1900 onwards and became a serious concern for the government. The government adopted the policy of quarantine to prevent the outbreak of plague. Under the Epidemic Diseases Act, 1897 and Plague Regulation of 1900 certain measures were taken for inspecting the persons who were travelling '*by railway or otherwise, and the segregation, in hospital, temporary accommodation or otherwise of persons suspected by the inspecting officer of being infected with any such disease...'*[28]

More importantly, the colonial government wanted to employ force *'for the purpose of carrying out the evacuation and disinfection of infected houses and villages prohibited...'*[29] But the indigenous people opposed this particular step for environmental sanitation as mentioned in an official letter dated 6th April, 1900. The author clearly stated, *'There was a general consensus of opinion that it was undesirable to employ force for this purpose partly*

because to do so prejudiced the people against the very measure by which it was sought to eradicate plague...'[30]

The vernacular journals like *SwasthyaSamachar, Swasthya*and others emphasised on the importance of environmental sanitation to prevent plague. These journals highlighted the importance of disinfection of houses and latrines with chemical disinfect and also with sun light, water purification, proper removal of night soil, efficient conservancy and drainage system, street lightening, introduction of tap water, cleanliness of streets etc.

In B.S. 1307, *Swasthya* published an article which stated, -

'Darkness, damp and dust are the potent agencies of disease. Dust of overcrowded streets, dust of congested human habitations harbour disease germs; darkness and dampness favour their growth.'[31]

From the above-mentioned passage it is evident that the indigenous people were familiar with the measures to prevent plague and took initiatives to create a public culture through their writings. But these writers also discovered a connection between poverty and plague. *Swasthya* once mentioned, - *'According to the great slogan of London, plague is poor man'sdisease. The poor people in Bengal live in dark and ill-ventilated rooms, which are very small in size and always overcrowded. They are also deprived of nutrition. These hard working people with insufficient diet very often become the victims of plague.'*[32]

C The Response of the Colonised: From an Intellectual & Socio -Cultural Perspective

(a) The writings of Sarat Chandra Chattopadhyay on the epidemics of Bengal – APrologue to the Bengali Society

Sarat Chandra Chattopadhyay, one of the famous novelists of colonial Bengal was appreciated by the critics for his soulful and thought provoking narratives of the Bengali society. He was very much aware of the then situation and through his writings depicted the reality in a lucid language.

In his novels like Panditmashai and Pallisamaj he not only mentioned the virulence of malaria and cholera (*vishuchika or ola-utha*), also portrayed the physical and mental agonies of indigenous people as a result of these ailments. The discrimination between rich and poor, the rigidity and fallacy of Hindu caste system were repeatedly highlighted by him as these were the chief enemies of the society along with the epidemics.

In the novel, Panditmashai, which Sarat Chandra wrote in 1911, the velocity of cholera was vividly described as it took away the lives of many. In this novel, the author did not mention any efforts from the Government to eradicate cholera. But the initiatives of the rural people perhaps were very few became the focal point.[33]

For example, Brindaban, an educated and rich villager was against of water pollution and tried to protect the pond owned by him. He did not allow one of the village women to wash the dirty cloths and blanket of a cholera patient just after his death. It created a huge tension as that person belonged from the upper caste and Brindaban was of low caste.[34]

Brindaban's efforts for environmental sanitation came to an abrupt end with the sad demise of his son Charan, who also became the victim of *vishuchika*.

In the last segment of the novel, Brindaban donated all of his wealth to construct a well for the supply of potable water which could also serve the needs of adjacent villages. He left village with the hope that perhaps this measure could prevent the outbreak of cholera in future as cholera had an intimate link with water contamination.[35]

In 1916, Sarat Chandra wrote Pallisamaj and described malaria as a deadly demon (*rakshashi*). The main character of the novel, Romesh, who was a land lord, hadnoble intention for reforms especially related to environmental sanitation.[36]

Being an engineer, he had understood the importance of clearance of dense forests, proper drainage and sanitation and covering up of rotten ponds. Unfortunately his subjects were reluctant to spend money for all these.

Romesh wanted to create an atmosphere of awareness amongst his subjects and had a great faith on his Muslim subjects of Pirpur. He also noticed the fluctuating growth of malaria from one place to another due to effective drainage and sanitation.[37]

In his novel, Srikanto (Second part), Sarat wrote on plague. He described a situation where Srikanto, the male lead, was physically examined by the European doctor before embarking the ship to Rangoon (Burma).Srikanto was inspected by the doctor to detect whether he had the symptoms of plague and this whole procedure was commonly known as '*pilegka dogdari'*.[38]

To describe the importance of western medicine in British rule, Srikanto stated, *'Einrajrajjyottedaktarerprobolpratap'*(the doctors are playing a vital role in the British rule).[39] Perhaps Sarat realised the importance of western medicine which acted as a significant tool to colonise the indigenous people.

Srikanto also got familiar with the term, 'Quarantine' (according to the indigenous people, *kerentin*) when he reached Burma.[40]

From this novel, we learn that, during the first half of the 20th century, the government of Burma took certain precautionary measures to prevent plague. Amongst them, quarantine was the foremost which caused both physical and mental harassments to those who came to Burma by sea route. These people had to stay in a distant place for ten days and their belongings were disinfected by steam.

But in some special cases, they used to get permission from the port health officer to enter the city and expected some relaxations.[41] This detailed description of quarantine helps us to understand the severity of plague which also made both the colonisers and colonised panic-stricken.

(b) Rabindranath Tagore & Patrick Geddes: The pioneers in Bengal to save environment

It is important to highlight the contributions of Rabindranath Tagore and Patrick Geddes who tried to make a heavenly place on earth and showed a genuine concern for environmental sanitation. They had a great respect for Indian culture and developed philosophic ideas on nature and ecology.

Rabindranath's Santiniketan, which established in 1901, was not only an epitome of learning it also encouraged the dwellers to practice and preserve ecology in a scientific manner rooted in Indian culture.

The *BasantaUtsav* (spring festival), *HalakarshanUtsav* (harvesting festival), *Briksharopana* (forestation), *Barshamongala* (cultural programme to welcome rainy season) and *PousUtsav (*winter featival) of Santiniketan started with the initiatives of Kabi Guru who wanted to create an eco-friendly divine atmosphere for the students of Visva Bharati.[42]

Patrick Geddes (1854-1932), the founder of 'Environmental Society' (1884) of Scotland, came to India to work for various projects on town –planning in 1915. He also helped Rabindranath to plan the campuses of Santiniketan and Sriniketan and earned his valuable friendship.[43] Both of them believed in *'theory of life in environment through generations'*.[44]' They spent their whole life to maintain the relation based on the philosophies of pragmatism, naturalism, divinity and humanism.[45]

Conclusion

The present paper has three sections. In the first section, a brief history of public health in Bengal is given to make the readers aware of the historicity of the situation. In the second segment the virulence of cholera and plague is described in the light of official documents and vernacular resources. In the last section, the writings of Sarat Chandra and the efforts of Rabindranath Tagore along with Geddes are mentioned to highlight the response of the Bengali intelligentsia regarding the conservation of environment and the maintenance of environmental sanitation.

The core of this paper is to emphasise the intimate link between insanitation and epidemics and how the need for a clean environment became important during the colonial rule. Both the colonisers and colonised gradually understood the fact that the only remedy for cholera and plague was effective sanitation.

The colonial officials in their documents meticulously pointed out the wretched condition of sanitation and the unwillingness of the natives for reforms. On the other hand, the superficial concern of the Government often negatedwith economic deficit.

The ailments like cholera and plague created tensions to a great extent as they were coloured with the notion of colonial politics. As water purification was closely associated with cholera prevention and from this perspective it made the local people hostile very often. These people mostly illiterate villagers both Hindu and Muslims resented the Government as they were against of any change.

The British Government strictly followed the policy of quarantine to eradicate plague which caused fear psychosis amongst the indigenous people. Numerous people fled from their native place, even lost their lives due to the fear of quarantine. The British officials mercilessly inspected both men and women which went against the Government. Sarat Chandra in Srikanto mentioned about '*pilegkadogdari'*which was definitely a common feature of the then society.

It may be noted that, the ailments like cholera and plague often took the form of an epidemic due to the callousness of the indigenous people. These man-made epidemics became the focal point of Sarat's novels as he mentioned in Panditmoshai. He had a deep concern for the society and tried to find out the lacunas within. He rarely blamed the Government and through his characters (like Romesh of Pallisamaj, who was an engineer) tried to spread the message of awareness.

Rabindranath through his Shantiniketan and Sriniketan projects wanted to preserve ecology and set in an example for the future generations. Here he got the help of Patrick Geddes, who was a Scot national, but genuinely felt for the Indians. This particular section does not have a direct link with the first two segments, but the efforts by Rabindranath and Geddes to save ecology and environment was surely a land mark in this direction.

Lastly, the vernacular writings on cholera and plague were vast and perhaps larger than the literature on malaria which was considered the deadliest amongst the other ailments. More importantly, through these writings the writers expressed their utmost concern for environmental sanitation. It is desirable to research more in this direction which will surely add a new chapter in the history of 20th century Bengal.

Notes & References

[1] *Martin, James Ronald* – 'Notes on the Medical Topography of Calcutta', *Calcutta, 1837, pp.23-24*

[2] Tenth Annual Report of the Sanitary Commissioner for Bengal (1877), Appendix No. VI, p. LXIX.

[3] Annual Report of the Sanitary Commissioner for Bengal (1868), Part-I, P.9.

[4] Ibid, pp.16-17.

[5] Ibid.

[6] Ibid.

[7] Cunningham, J. M. – '*Cholera: what can the State do to prevent it'*, Calcutta, 1884, pp. viii-ix, cited by Goswami, Tinni in *'Tropical Diseases in India –in the Eyes of the British – A Question Arising from the study of Medical Literature of the 19th Century'*, published in Quarterly Review of Historical Studies, Vol. xxxxx, Nos. 1 and 2.

[8] Annual Report of the Sanitary Commissioner for Bengal (1868), pp. 103-108.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] Surgeon Cornish, W.R. – '*Cholera in Southern India (1870),*' published from Madras in 1871, p.4.

[13] Townsend, S.C. – *'Memorandum on the precautions to be taken against Cholera'*, p.1, year not found.

[14] Harrison, Mark – *'Public Health and Preventive Medicine in British India, 1859-1914'*, Cambride University Press, 1994, p.122.

[15] Eleventh Annual Report of the Sanitary Commissioner (1878), p.16.

[16] Ibid.

[17] Sanitary Commissioners Form No. 18, No. 1932, From the Sanitary Commissioner for Bengal, to the Secretary to the Government of West Bengal, Municipal Department, dated Calcutta, 13th March, 1889.

[18] Ibid.

[19] Thirty-Third Annual Report of the Sanitary Commissioner for Bengal, pp. 20-22.

[20] Ibid.

[21] Sarkar, Dr.Abhoy Kumar – *'Olautha Roger Pratikar o Chikitsa'*, Faridpur, B.S.1335, pp. 89-95.

[22] Thirty-Third Annual Report of the Sanitary Commissioner for Bengal, pp. 18-19.

[23] *SwasthyaSamachar, Chaitra*, B.S. 1332.

[24] Maitra, Dr.Jnan – *'Practical Cholera Treatment'*, 1930, pp.1-10.

[25] Ibid.

[26] *SwasthyaSamacharPatrika*, Srabon, B.S. 1326.

[27] *'Observations on Plague in Eastern Bengal And Assam'*, 1910, pp. 158-165.

[28] '*The Bengal Plague Manual*', Calcutta, Bengal Secretariat Press, 1903, Chapter – 1.

[29] Ibid, Chapter – 3, p.30.

[30] Ibid, pp.30-31.

[31] *Swasthya, Jaistha*, B.S. 1307.

[32] Ibid, *Chaitra*, B.S. 1307.

[33] Chattopadhyay, Sarat Chandra – *'Panditmasahi'*, 1914, *passim*.

[34] Ibid.

[35] Ibid.

[36] Chattopadhyay, Sarat Chandra – '*Pallisamaj*', 1916, *passim*.

[37] Ibid.

[38] Chattopadhyay, Sarat Chandra – '*Srikanto,'* Second part, 1918, *passim.*

[39] Ibid.

[40] Ibid.

[41] Ibid.

[42] Banerjee, Arunendu – *'Rabindranath Tagore and Patrick Geddes, The Ecological Visionaries'*, The Asiatic Society, Kolkata, 2005, pp. 9-16.

[43] Ibid.

[44] Ibid.

[45] Ibid.

Tracking Tigers, Writing Wildlife

''Never attack a tiger on foot—if you can help it. There are cases in which you must do so. Then face him like Briton, and ill him if you can; for if you fail to kill him, he will certainly kill you''

—Walter Campbell

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In his foreword to the *Tigers of the Raj: The Shikar Diaries of Colonel Burton 1894 to 1949*, Colonel Richard Burton, a Cantonment magistrate in India, cites a verse entitled 'A Father's Advice to his Son' written by Eric Parker: 'If a sportsman true you'd be, / Listen carefully to me. / Never, never let your gun / Pointed be at anyone; / That it may unloaded be / Matters not the least to me.' The verse extract moves on to advise prospective ruling hunters in a rather amusing manner. Yet, beyond the lighter note,the plethora of shikar diaries of the days of the British Raj, testify to the topicality of the verse extract. Burton, who had served as a Cantonment Magistrate in India for over five decades, was regarded as an authority on the big game hunting in India. Beyond his professional work he was actively involved as a hunter and during the later years of his stay in India he became a conservationist. Burton's diaries testify to the larger widely prevalent culture of the big game. Not only high ranking British officers, but soldiers too actively participated in this sport. In this analysis, the paper intends to delineate the efforts directed in preparation of the big sport of tiger hunting. The preparatory efforts reveal the extreme importance British hunters gave in pursuit of big game hunting.

In his volume entitled *I was a Tiger Hunter* J. Moray Brown outlines the general modus operandi of tiger hunting very briefly:

> Our shikari was sent out over the ground we proposed traversing during the trip, some six weeks previous to our start. It was then his business to make all inquiries respecting the localities in which tigers were to be found, their habits, and the particular spots they were in the habit of frequenting, and of their characters; for, strange as it may seem, nearly every tiger has a certain character for ferocity, wiliness, or the reverse—of being a man-eater, cattle, killer, or game killer— which are well known to the jungle folk.
>
> At the end of six weeks the shikari would return and make his report, saying two tigers had taken up their abode near such and such a village, another near so and so, and so on. To these points in rotation, according as they presented the most convenience on our line of march, we directed our camp.

> On arrival the shikari would, by inquiry and personal inspection of the jungle, satisfy himself that the tiger, or tigers were still in the vicinity. This he would do by looking out for fresh tracks. (Brown 128)

Without the help of the local villagers and local shikaris, the sahib found it extremely arduous in locating and hunting the tiger. As local jungle lore would have it, in some instances, in certain villages 'inhabitants would really be sorry to have the tiger they have known for so many years, and at whose hands they have suffered great losses in the way of cattle, harassed or killed by an European sportsman.' (Hackle 4)This strange behaviour on the part of the local population was indeed very difficult to explain. Ridden with superstitions, a common belief among the local masses was that 'the spirit of the dead tiger will haunt those that have been instrumental in his death'.The British sportsman going for the tiger hunt had to take cognizance of the local superstitions, legends and beliefs. One such incredible belief among the jungle folk was that 'the spirit of the victim of a man-eating tiger rides about at night on the forehead of its slayer and warns the animal of the approach of danger.'(Hackle 5)

Most of the shikar diaries, jotted down during the days of the British Raj, outline the different methods by which tigers were commonly shot or hunted down in India. The broad approaches included shooting the big cat from elephants, beating in the jungles with the aid of groups of locals, luring the tiger with a bait of domestic animals, and finally shooting the animal on foot. Of these various methods of killing the animal, the last one, i.e. by foot was regarded as the most dangerous and challenging one. As one of the practitioners warns about hunting by foot: 'No one should make it a practice of shooting these animals on foot, for if he does so, sooner or later his shooting days will come to an abrupt end, either by his being killed or being badly and hopelessly maimed for the remainder of his days.' (Hackle 33) In this context it is especially important, as most diaries affirm, to be extra vigilant about the wounded tiger, which under no circumstance should be followed up immediately. Leaving the wounded tiger alone for the night 'will either give him time to die of his wounds, or at least reduce his strength to such an extent as to make him less dangerous to tackle.' (Hackle 37)

In sharp contrast and in accordance with most shikar diaries and other memoirs, the sport of shooting tigers off elephant rides was relatively less risky and less fraught with dangers. Shooting tigers astride elephant rides was by and large prevalent in those parts of India where there are extensive stretches of open grass lands, especially in parts of the North eastern India and in the Nepal terai regions. As one of the memoirs describes:

> Elephants can be used in different ways in hunting down tiger; sometimes proceeding in a line and beating him out of a patch of jungle towards the sportsmen, posted ahead, also on elephants, in the direction the animal is likely to take; at other times they are used for ringing round the patch of jungle in which the tiger has been marked down, and then in dense formation closing in on him, when the sportsmen from their howdahs finish off the beast as it charges or sneaks around in its efforts to find an opening through the densely packed ring of elephants.Another method of using elephants is to systematically go through every patch of jungle on the mere chance of putting a tiger up, and, as a very large area of ground can be covered in this fashion, should it be good tiger country, the chances are that a tiger will be put up sooner or later during the day. (Hackle 38)

It is in the task of tracking a wounded tiger that hunting off an elephant back proves to be most effective and useful, as from an elevated position it is easier to catch a glimpse of the wounded cat.Hunting astride the elephant carried with it the danger of incurring extra expenses, in case the elephant was injured in the process of the execution of the act.However, the method of hunting that was most popularly used was that of using local people and beat-

ing for them. This mode required a great deal of meticulous planning for successful execution. Most shikar diaries provide a general outline of this mode of hunting:

> On arrival at his shooting grounds, the sportsman should, with the help of the local inhabitants, get to learn as much of it as he can; and finding out the runs of tigers, select spots … for tying out one or two young buffaloes (or bullocks, if not offensive to local religious principles). The feeding, watering and bringing home of these animals in the morning, if still alive, should be delegated to special men. As soon as a "kill" is reported, men should be sent round to the closest villages to collect beaters, who should assemble either at the sportsman's camp or at some pre-arranged spot near, but not within hearing of, the jungle to be beaten. (Hackle 41)

As regards the time of approach of the huntsman, the instructions are quite clear:

> The sportsman, about midday when the tiger is lying up gorged with his overnight's meal near his "kill", should proceed to the spot, and as silently as possible have a *machan* erected – if not already put up—on a tree in direct line the tiger is likely to take as soon as the beat starts. Whilst the *machan* is being put up, he, either personally or through his shikari, puts men up different trees on either flank, with the lines spreading out from the point of his *machan* in the shape of a triangle or arc, with the line of beaters as the base. (Hackle 41)

The diaries further provide precise instructions. The area which is to be beaten is not only enclosed but surrounded by local inhabitants on all sides. The beaters not only yell while hitting trees with their axes but close in upon the enclosed area with the intention of gradually driving the big cat towards the *machan* in close vicinity of the sportsman. For the *shikari,* the focus is on the tiger, as and when it emerges from within the enclosed area. The animal was usually shot at within the range of the *machan.* Yet, the success of the execution through this method of tiger hunting depended on a large number of other factors. In this context the general advice was to prepare the bait, in the form of buffaloes or goats, at strategic junctions in the forest, which, ideally, as suggested should be near some water hole. The logic behind this suggestion was the likelihood of the big cats taking a drink in the post- meal period. Successful hunters also recommend in their diaries, the presence of thick cover of bushes or long grass in near vicinity for the big cat to drag his/ her meal. Beyond the primary recommendations of water and some sort of bush thicket cover, the writer further cautions that 'the sportsman must see that the general configuration of the country is suitable for beating; for if there should be any troublesome hills close by, or the jungle be one continuous sheet of forest, the beat is not likely to be successful' (Hackle 42) In this context, suggestions have also been made of the ideal patch for tiger hunting:

> The ideal patch to get a tiger to lie up in an isolated and detached piece of forest with only one or two distinct natural leads to heavier forests; even a block cut out of a large forest, so long as it is circumscribed by roads, forest lines or nullahs, makes a capital beat. The beat itself should rarely exceed half a mile in length, as anything longer would afford too many loopholes for the tiger to get through. (Hackle 42)

Huntsmen also caution against leopard infested areas. While most jungles were co-habited by leopards or panthers, particular attention had to be given so that the bait was not taken away by any other big cat. Usually most forests had places which were recurrently used for baits for tigers. In this context it is interesting to note that successful hunters have also given suggestions for the nature of rope to be used for tying the bait. The rope accordingly should be 'weak enough to be broken by the tiger, and yet strong enough to hold the tethered animal.' (Hackle 44).

The spot for constructing the *machan* has also been strongly advised in most diaries. The suggestion is to erect it on the fringes of the jungle to be beaten, and certainly not across a road or forest line or open spaces. It must not be placed in close proximity of *nullah*: 'it is a

mistake to place a *machan* in a narrow *nullah*, for though he may use the *nullah* at night, when frightened he will generally go along the banks of it, from where he can obtain a better view, knowing he can always slip into the *nullah* should it be to his advantage' (Hackle 46).The *machan,* as the memoirs suggest should be strategically constructed at a height of fifteen to sixteen feet from the ground. The advantage of this extra height is clearly mentioned as 'from this extra height the sportsman's bullet is less likely to ricochet, and there is less chance of the *machan* itself being seen by the tiger.' It is also suggested that the *machan* is strong and sturdy enough to endure. It can be home made and carried to the spot instead of being made on the location.In this context it is interesting to learn that most locals who participated in the sport were drawn to it for the money that they were paid. In the days of the Raj, the beaters were usually paid four *annas*. But if a tiger was bagged, the amount was likely to double. The *shikari* was usually rewarded with ten rupees which was beyond his normal wages.

From the elaborate arrangements and planning efforts directed towards making preparations for tiger hunting in the Indian jungles (as mostly advocated and discussed in the diaries of several sportsmen during the days of the British Raj) it is clear that the big game hunting was extremely popular during the days of the colonial rule. From initial assertion of masculinity and self-aggrandizement, this interest gradually went out of control, paving the way for hunter conservators like Jim Corbett and several others to moot conservation plans in the long run.

Works Citied

Brown, J. Moray I was a Tiger Hunter (Gloucestershire: Amberley Publishing, 2014) pp. 128-130

Burton, Richard Colonel *Tigers of the Raj: Pages from the Shikar Diaries—1894 to 1949 of Colonel Burton, Sportsman and Conservationist,* edited by Jacqueline Toovey (Guernsey: Alan Sutton Publishing Limited, 1987)

Campbell, Walter *My Indian Journal* (Edinburgh: Edmonston and Douglas, 1864) p.162

Corbett, Jim in *Tigers and Tigerwallahs* edited by Geoffrey Ward with Diane Raines Ward pp. viii to xii

Hackle, Silver *Indian Jungle Lore and the Rifle* (Calcutta and Shimla: Thacker, Spink& Co, 1929) pp.2-50.

A Study on Chromium (Cr^{+6}) Induced Biological Changes in *Channa* sp.

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Abstract

Environmental pollution affects the quality of hydrosphere, atmosphere, lithosphere and biosphere. Great efforts have been made in the last two decades to reduce pollution sources and remedy the polluted soil and water resources.

An attempt has been made in the present investigation to determine the toxicological effects on survival, physiological, hematological system through different biochemical parameters on widely consumed Indian minor carp *Channa* sp. Short term and long term acute toxicity tests were performed over a period of 24 hr to 96 hr using different concentrations of hexavalent Chromium. The results showed that the normal respiratory activity of the fish was significantly affected. The metal induced physiological changes like appreciable decrease in the biochemical profile like total protein, acid phosphatase (ACP), alkaline phosphatase (AlkP) and lipid peroxidase (LPO) activities and increase in the aspertate amino transferase (SGOT) and alanine amino transferase (SGPT) level were noticed. The metal induced significant decrease in the hematological parameters like erythrocyte count, hemoglobin percentage indicating anemia.

Introduction

Although conceptually distinct, Risk Assessment and Risk Management are often impossible to separate in practice. Risk assessment is essentially a preliminary to setting up proper risk management procedures.

Adverse effect Heavy Metals (Pb, Cr, Cd, Fe, Zn, Cu, Hg etc.) disturbs aquatic life (Ambrose. et. al 1994). These metals accumulated in aquatic ecosystems as a result of land based activities. Hexavalent Chromium (Cr^{+6}) from Potassium dichromate ($K_2Cr_2O_7$) have been found to be mutagenic and more carcinogenic to aquatic organism. It is more important valence in toxicity standpoint. Unlike Trivalent Chromium (Cr^{+3}), hexavalent Chromium (Cr^{+6}) is readily absorbed by all tissues, enter the cells via the general anion channel protein.

The chronic effect of hexavalent Chromium (Cr^{+6}) on *Channa* sp. were investigated and by the effective procedures.

MATERIALS AND METHODS

An attempt has been made in the present investigation to determine the acute toxicity and toxicological effects on survival, physiological and hematological system through different biochemical parameters on widely consumed Indian minor carp *Channa* sp. Short term acute toxicity tests were performed adopting bioassay technique over a period of 96 hrs using different concentration of 7.5 ppm and 15 ppm of Cr^{+6} conc. In water, total protein, lipid peroxidase activity was observed and at the same time SGOT and SGPT level were also observed.

Channa sp. fishes of equal size (25 gm – 30 gm) were reared in water treated with $K_2Cr_2O_7$ at 7.5 ppm and 15 ppm conc. separately for 24 hrs, 48 hrs, 72 hrs and 96 hrs. Liver and spleen were collected from fish for biochemical studies and blood collected for hematological studies. Quantitative estimation of total protein, the method of Lowry. et. al. 1951 was used. For SGOT and SGPT, the method of Berg Meyer H. U and Brent, E (1974), and for LPO, the method of Buege. J. A and Aust, S. D (1984) was used.

Fig 1. Affected liver of *Channa* sp. After exposure of 15 ppm concentration of Cr^{+6}

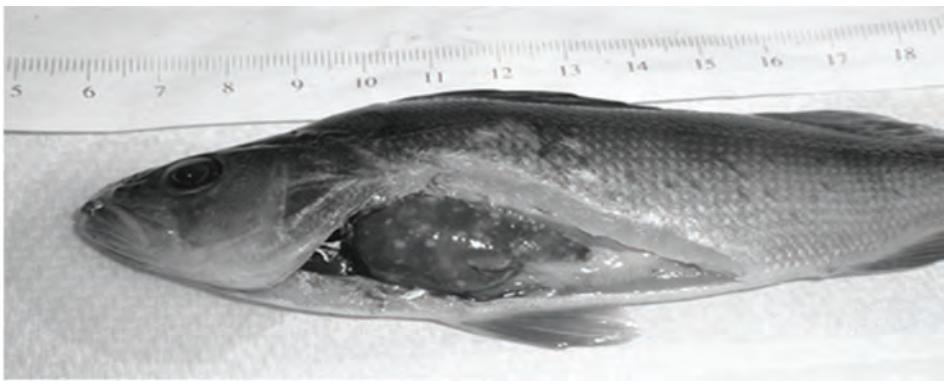

Fig 2. Healthy liver of *Channa* sp.

Results

From the above study, due to chemical effect, the total protein estimation reading from liver extract was fluctuated along with duration of exposure of fish in the treated water.

Table 1A Result of SGOT activity

Tissue taken	Normal	Conc.	Treated*					
			24 hr	significance	48hr	Significance	96hr	Significance
Liver	0.0034 ±0.0002	7.5 mg/1	0.0044 ± 0.0001	P<0.01	0.0018 ± 0.0002	P<0.01	0.0088 ± 0.0001	P<0.01
		15 mg/1	0.0070 ± 0.0001	P<0.01	0.0042 ± 0.0001	P<0.01	0.0145 ± 0.0007	P<0.01
Spleen	0.0023 ±0.0001	7.5 mg/1	0.0036 ± 0.0001	P<0.01	0.0048 ± 0.0017	P<0.01	0.0091 ± 0.0005	P<0.01
		15 mg/1	0.0027 ± 0.0001	P<0.01	0.0021 ± 0.0001	P<0.01	0.0096 ± 0.0002	P<0.01

* Results on the basis of 3 replicates / treatment

The result of SGOT activity revealed that the liver was increased sharply from normal at 24 hr at 7.5 ppm conc. with a sharp decline at 48 hr and then again gradual increase at 96 hr. The same trend observed at 15 ppm conc. and SGOT for spleen, showed sharp increase from 24 hr to 96 hr.

Table 1B Result of SGPT activity

Tissue taken	Normal	Conc.	Treated*					
			24 hr	significance	48hr	Significance	96hr	Significance
Liver	0.0013 ±0.0017	7.5 mg/1	0.0012 ± 0.0001	P<0.01	0.0072 ± 0.0002	P<0.01	0.172 ± 0.0035	P<0.01
		15 mg/1	0.0022 ± 0.0002	P<0.05	0.0029 ± 0.0001	P<0.05	0.0300 ± 0.009	P<0.05
Spleen	0.0009 ±0.0001	7.5 mg/1	0.0011 ± 0.0001	P<0.05	0.0026 ± 0.0003	P<0.05	0.0080 ± 0.0001	P<0.05
		15 mg/1	0.0022 ± 0.00003	P<0.005	0.0042 ± 0.0002	P<0.01	0.0091 ± 0.0001	P<0.05

* Results on the basis of 3 replicates / treatment

The SGPT enzyme activity of liver showed little (48 hr) to abrupt increase at 96 hr for 7.5 ppm and 15 ppm conc. whereas for spleen, the result showed gradual and moderate increase. The comparison showed that the liver is the more affected organ.

Table 1C Result of LPO activity

Tissue taken	Normal	Conc.	Treated*					
			24 hr	significance	48hr	Significance	96hr	Significance
Liver	0.0002 ± 0.000005	7.5 mg/1	0.00026 ± 0.00008	P<0.01	0.00020 ± 0.00005	P<0.01	0.00016 ± 0.00005	P<0.01
		15 mg/1	0.0001 ± 0.00008	P<0.01	0.000075 ± 0.00001	P<0.01	0.000049 ± 0.00001	P<0.01
Spleen	0.00010	7.5 mg/1	0.00007 ± 0.00001	P<0.01	0.000062 ± 0.00002	P<0.01	0.000061 ± 0.00002	P<0.01
		15 mg/1	0.000041 ± 0.00001	P<0.01	0.000031 ± 0.00001	P<0.01	0.000011 ± 0.00001	P<0.01

* Results on the basis of 3 replicates / treatment

Lipid peroxidation (LPO) is the most important enzyme activity test to identify the liver and spleen. It showed for liver, the gradual decline in enzyme activity from 24 hr to 96 hr for the conc. 7.5 ppm and 15 ppm of Cr^{+6} treatments.

BAR DIAGRAM OF LPO ACTIVITY

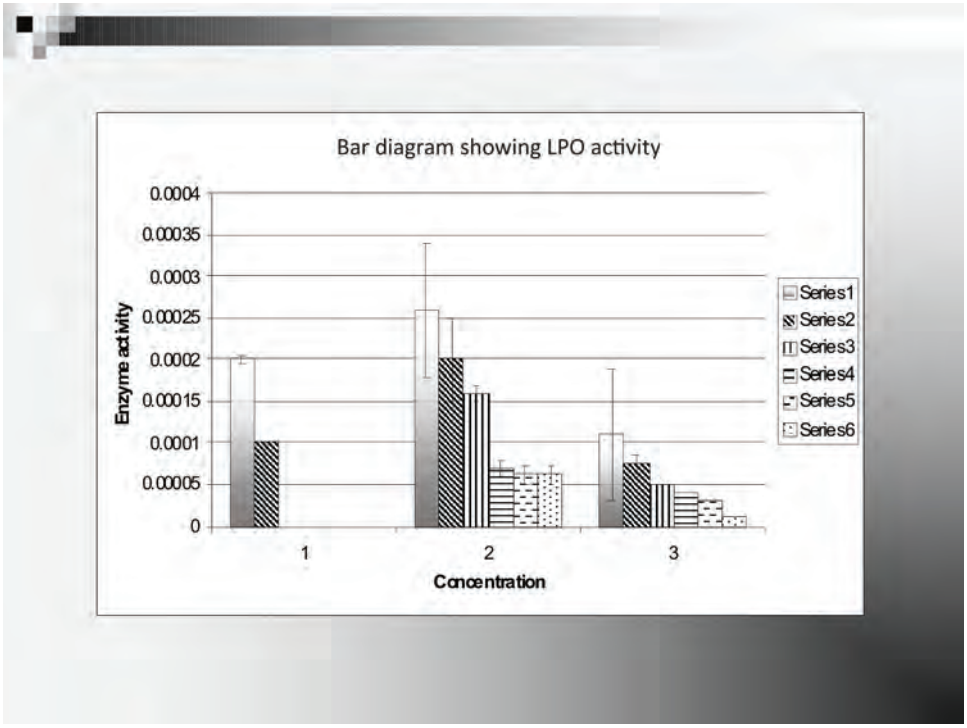

Table 2 Result of Hematological parameters

Normal			Conc.	Treated*											
				24 hr				48hr				96hr			
Mean blood cells	Mean Lymb hocy tes	%		Mean blood cells	Mean Lym-phoc-ytes	%	sig nifi can ce	Mean blood cells	Mean Lym-phoc-ytes	%	Sig nifi can ce	Mean blood cells	Mean Lym-phoc-ytes	%	Sig nifi can ce
2442 ± 62.0	0440 ± 12.08	17.84	7.5 mg /1	1774 ± 36.52	0265 ± 11.28	14.90	P< 0.05	1632 ± 22.33	0197 ± 3.87	12.13	P< 0.01	1233 ± 9.41	0102 ± 5.06	08.29	P< 0.05
			15 mg /1	1255 ± 72.32	0210 ± 18.05	16.69	P< 0.05	1361 ± 34.37	0172 ± 10.23	12.43	P< 0.05	18.62 ± 47.93	0121 ± 8.75	06.52	P< 0.01

* Results on the basis of 3 replicates / treatment

From the study of lymphocyte count it was evident that the number of lymphocyte gradually decreases at different time intervals 24 hr, 48 hr and 96 hr. when compared with normal in both 7.5 ppm and 15 ppm conc. of Cr^{+6} treatment. The rate of decrease of lymphocyte was remarkably high in 15 ppm conc. than in 7.5 ppm conc. of Cr^{+6} treatments.

Discussion

Chromium toxicity is apparent in the water body because of the presence of tannery effluences (ref: APHA, AWWA, WPCP; 1998.). This chromium can easily show hyper accumulation in the body of fishes and will be toxic to different soft tissue like liver and spleen (ref: Berg Meyer HU Brunt1974). It also can modify the hematological parameters(ref: Mahipal singh 1995).

In the present investigation, the authors have studied Cr^{+6} toxicity and there has been significant modification in liver and spleen. The Cr^{+6} toxicity is also apparent in remarkable changes in the hematological parameters. It can be concluded that Cr^{+6} via fish food can enter into mammalian system including human being and induce long term toxicity.

References

Ambrose, T., Cyril Arun Kumar, L., Vincent, S. Rosenlyn Lambert 1994. Biochemical responses of *Cyprinus carpio* communis to toxicity to tannery effluent. *J. Ecobiol* 6(3):213 – 216.

APHA; AWWA; WPCP; 1998. Standard methods for the examination of water and waste water. *20th edn. American Public Health Association*, Washington DC.

APHA (American Public Health Association) 2005. Standard methods for the examination of water and waste water. *21st APHA, AWWA, and WEF*, Washington DC.

Bailey, N. T. J. 1959 Statistical Methods in Biology. The English Language Book Society: Great Britain, pp 200.

Berg Meyer HU Brent E. 1974. Methods of Enzymatic Analysis, (Ed: Berg Meyer HU), Verlag Chemic Weinhein, Academic Press, New York, Vol 2, 735 – 760.

Buege JA and Aust SD (1984). Microsomal Lipid Peroxidation. Methods Enzymol 105: 302 – 310.

Chen HM, Zeng CR, Tu C, Shen ZG. 2000. Chemical Methods and Phytoremediation of Soil Contaminated with Heavy Metals. Chemosphere: 41, 229 – 234.

Djingova R, Kuleff I. 2000. Instrumental techniques for trace analysis in trace elements: their distribution and effects in the environment. Vernet, J. P. (Eds) Elsevier Science Ltd. United Kingdom, pp. 146.

Hawkesford M J. 2003. Transporter gene families in plants: the sulfate transporter gene family – redundancy or specialization? Physiol. Plant. : 117, 155 – 163.

Ikhuoria EU, Okieimen F E. 2000. Scavenging Cadmium, Copper, Lead, Nickel and Zinc ions from aqueous solution by modified cellulosic sorbent. Int. J. Environ Studies. : 57(4), 401.

James, R. K.; Sampath, K.; Punithavati Ponmani, K. 1992. Effect of metal mixtures on activity of two respiratory enzymes and their recovery in Oreochromis sp. Ind. J. Exp. Biol.: 30, 496 – 499.

Jadia CD, Fulekar MH. 2008. Phytotoxicity and remediation of heavy metals by fibrous root grass (sorghum). Journal of Applied Bioscience (2008). (10): 491 – 499, ISSN 1997.

Kuzovkina YA, knee M., Quigley, MF. 2004. Cadmium and copper uptake and translocation in five Willow (Salix L.) species, Int. J. Phytoremediation. : 6, 269 – 287.

Lowry, O. H., Rosebrough, N. J., Lewis Farr, A., Randall, R., 1951. Protein measurement with Folin Phenol Reagent. J. Biol. Chem. : 193, 265 – 275.

Mahipal Singh. 1995. Haematological responses in a freshwater teleost, *Channa* sp. to experimental copper and chromium poisoning. J. Environ. Biol. : 16, 339 – 341.

Manohar S, Jadia CD, Fulekar MH. 2006. Impact of Ganesh idol immersion on water quality. Indian J. Environ. Prot. : 27 (3), 216 – 220.


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