



# Air Pollution, Noise, Meteorology and traffic: Monitoring and Correlation at a site selected in Delhi

Kirti Bhandari<sup>1\*</sup>, Nisha Kumari<sup>2</sup> & Mamta Batra<sup>3</sup>

<sup>1</sup> Principal Scientist, Transport Planning Division, Central Road Research Institute, New Delhi. 110025, India

<sup>2</sup> Assistant Professor, Deenbandhu Chhotu Ram University of Science and Technology, Murthal-Sonapat (Haryana)-131039

<sup>3</sup> Student, Deenbandhu Chhotu Ram University of Science and Technology, Murthal-Sonapat (Haryana)-131039  
Kirti.bhandari7@gmail.com

\*Corresponding author's E-mail: kirti.bhandari7@gmail.com

(Received: August 24, 2014; Accepted: September 10, 2014)

## Abstract

This paper analyzes the state of environment at a selected site in Delhi. The impact on air quality and noise due to traffic has been monitored and correlated. In addition to this, effect of meteorological conditions on air pollutants was also studied. The following indicators of air quality including CO, O<sub>3</sub>, SO<sub>x</sub> and NO<sub>x</sub> have been monitored. These pollutants can have both acute and chronic effects on human health. Meteorological Parameters like wind speed; wind direction, relative humidity and temperature were also monitored using air pollution monitoring Van. The present day study was conducted at Okhla Subzi Mandi. The noise levels in terms of L<sub>10</sub>, L<sub>50</sub>, L<sub>90</sub>, L<sub>eq</sub> have been measured using digital Sound Level Meter. Finally Pearson correlation between air pollutants, noise, meteorology and traffic has been calculated using SPSS. Noise level study shows the variation during peak and non peak hours.

**Keywords:** Traffic, Air Pollutant, Emissions, Noise, Meteorology

## Introduction

Transportation is a non separable part of any society. Advances in transportation has made possible changes in the way of living and the way in which societies are organized and therefore have a great influence in the development of civilizations. But transportation has negative impact on environment which cannot be ignored. Enormous increase in number of vehicles has resulted in increase in emission of air pollutant. The increasing Vehicle emission has given rise to a significant increase in atmospheric pollutants which may have an impact on human health. Traffic-related emissions are a complex mix of pollutants comprised of nitrogen oxides, particulate matter, carbon monoxide, sulphur dioxide, volatile organic compounds, ozone, and many other chemicals such as trace toxics and greenhouse gases. Traffic contributes

more to ambient pollution in developing countries, accounting for upwards of 40-80% of NO<sub>2</sub> and CO concentration. This situation is alarming and is predicated on the poor economic disposition of developing countries. Transport related emissions are the major sources of air contamination, increasing civil construction activities also contribute to particulates. Due to continual traffic growth and emissions and their impact on human health and urban air quality there is an urgent need for a regulatory framework for the management of traffic, air quality and emissions at local level, as well as at regional and national scales. Awareness of air contamination and measures to monitor and control air quality are inadequate considering the rapidity of increase in pollution levels. Air pollution harms every living being, more so the

human population and in particular target severely the occupational groups like car drivers, traffic police personnel, parking lot attendants, tunnel workers, road side vendors, owners and employees of uncovered or frequently open commercial establishments in traffic dense, and all users of public places like bus stands, workshops and cinema theatres.

### Transport emissions and air quality

Traffic has a major impact on air quality in the Delhi. The emissions from transport and particularly from vehicles are the major sources of air pollution. Air pollution is an important environmental issue that harms every living being. The alarming Pollution levels have blackened the Delhi's air and its ever increasing number of vehicles responsible for this situation. About 60 percent of air pollution in Indian cities is due to automobile exhaust emission. Various contaminants continuously enter the atmosphere through natural and man-made processes and these contaminants interact with the environment to cause disease, toxicity, environmental decay that are commonly known as pollutant causing threat to human health. Sulphur dioxide, nitrogen dioxide and suspended particulate matter are regarded as major air pollutants in India. The chief source of vehicles pollution is the fuel (i.e. petrol and diesel) itself. The way it undergoes combustion inside the engine determines the amount of pollutant emissions from the engine. Internal combustion engines of automobiles emit carbon monoxide, hydrocarbons, oxides of nitrogen, lead, road and tyre dust, carbon particles. There are large number of two stoke two wheelers in Delhi which are the major contributors of air pollution. Vehicular exhaust includes carbon monoxide, nitrogen and sulphur oxides, unburned hydrocarbons, particulate matter, and polycyclic aromatic hydrocarbons. Generally petrol-driven vehicles emit more unburnt petrol and carbon monoxide whereas diesel driven vehicles emits more soot (suspended particulate matter) and oxides of nitrogen. Diesel vehicles are most important contributor air pollution in Delhi. The increasing number of diesel cars has increased the emission of NOx. Diesel exhaust generates pollutants like hydrocarbons, oxides of nitrogen and carbon is a major contributor to air pollution.

The study for the measurements of traffic pollutants was carried out using a mobile laboratory, called "sniffer", that was designed and built by the Laboratory of Automotive Engineering of Helsinki Polytechnic.

Construction of the sniffer is part of a Finnish national project LIPIKA. The mobile laboratory provides measurements of particles, some gaseous pollutants, meteorological and geographical parameters with high spatial and time resolutions. The particles are charged, size classified by inertial impaction and electrically detected. The mobile laboratory was fitted with the monitors and meteorological sensors. CO, NOx and O<sub>3</sub> data together with meteorological parameters such as wind speed, temperature, relative humidity, were analyzed by multiple linear regression using the RATS (Regression Analysis Time Series) programme. The results from this study show that there are moderate relationships between the meteorological parameters and CO in. However, there are weak relationships between the meteorological parameters and NOx. There are good relationships between the meteorological parameters and O<sub>3</sub>.

In an another study data for micro meteorological conditions required for air quality assessment viz. temperature, wind speed, solar radiation, rainfall and relative humidity were collected from the U.S. National Climatic Data Centre (NCDC) for Ahmedabad. Gridded rainfall data at 1° longitude – 1° latitude resolution were collected from the India Meteorological Department. These basic statistics include maximum, minimum, mean, and standard deviation of each variable. In this study the Pearson correlation analysis has been performed between particulate pollutants and meteorological data (wind speed, temperature, rainfall and relative humidity) to investigate the relationships between them. Traffic density was estimated via manual counting using tally system. Data were analysed using descriptive statistics, ANOVA and Pearson correlation test at 5% level of significance. These values exceeded the WHO guideline limit for CO (10ppm), SO<sub>2</sub> (0.17ppm), NO<sub>2</sub> (0.17ppm). There was a significant positive correlation between SO<sub>2</sub> and traffic density.

### Air quality modelling

A literature review was performed on commonly used pollution model to calculate the concentration of pollutants. The Carbon Monoxide (CO) concentration can be monitored and was compared with the National Ambient Air Quality Standards and the CO values were predicted by using CALINE4 and IITLS and Linear regression models. The study has revealed that linear regression model performs better than the CALINE4 and IITLS models. Some of the

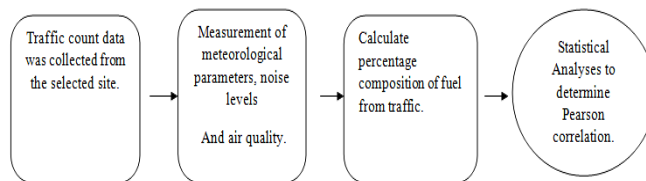
dispersion models developed includes the California Line Source. Dispersion Model - CALINE 4 in 1989, Indian Institute of Technology Line Source Model (IITLS) developed for traffic conditions in Delhi, General Finite Line Source Model developed by Luhar and Patil in 1989 and Delhi Finite Line Source Model in 1996. Environmental Analysis Model was developed using CALINE 4 and spatial data analysis wherein a GIS framework was used in the identification of pollution hot-spot. Operational Street Pollution Model (OSPM) is a semi-empirical model which can be used to calculate concentrations of vehicular pollutants. OSPM calculates contribution from i) direct vehicular exhaust ii) recirculation of pollutant within canyon due to vortex formation and iii) background concentration. OSPM uses Gaussian plume model to calculate direct contribution from vehicular exhaust whereas recirculation is modelled using a box model technique. The input data required by OSPM include: Traffic volume, Source strength, Meteorological data such as wind speed and direction at 10m height, Solar radiation data, Canyon geometry such as length, width and orientation of the street and height of buildings surrounding street and Background concentrations..

AERMOD is a steady-state Gaussian plume model. It uses a single wind field to transport emitted species. The wind field is derived from surface, upper-air, and onsite meteorological observations. CALPUFF is a non-steady state Lagrangian puff dispersion model. The advantage of this model over a Gaussian-based model is that it can realistically simulate the transport of substances in calm, stagnant conditions, complex terrain, and coastal regions with sea/land breezes.

## Materials and Methods

The framework is designed to be carried out in four phases as shown in Fig 1. The objective of this study was to monitor the level air pollutants emitted from traffic in the Delhi and develop the relationship between air pollutant, traffic and metrological conditions. The study was conducted on 2 February, 2013 in Okhla Subzi Mandi, Delhi. The Mandi was spread over an area of approx 10 Acres. Traffic density was estimated via manual counting using the tally system. Four research assistants were recruited to count the number of cars, buses, bikes and trucks that pass through the sampling points for a period of 15 minutes and this was used to estimate the hourly traffic density. Traffic count was conducted three times a day, morning, afternoon and evening. An observational

checklist was used to describe the characteristics of the study location. The measurement of traffic-related air pollutants levels comprising carbon monoxide, Sulphur dioxide, Ozone and Nitrogen dioxides were determined using mobile Air pollution monitoring Van. The measurements were made with a mobile air-quality measuring analyzer, equipped air pollution monitoring van. The measurement analyzer is fully automatic and computer controlled. To prevent measurement errors, the analyzer was calibrated in the certain periods. In addition, data for meteorological parameters like wind speed and direction, temperature and relative humidity ratio has also been collected from the Mobile Van. For the interpretation of data the following statistics were used: the raw data obtained was analyzed using descriptive statistic and Pearson's correlation was used to determine correlation between pollutants, meteorological, Noise and traffic data. In our study we are concentrating on the monitoring of ambient air along with traffic and meteorological condition. The aim of this research is to determine the relationship between air pollution, meteorology, noise and traffic.



**Figure 1.** Research Framework

## Methodology and Observation

The site selected for the study was Okhla Subzi Mandi, New Delhi. The Mandi is spread over an area of approx 10 Acres. Observations were taken for 24 hours at an interval of one hour.

## Traffic Density Estimation

Traffic density was estimated via manual counting using the tally system. Four research assistants were recruited to count the number of cars, buses, Goods vehicles and other motorised vehicles that pass through the selected location for a period of 15 minutes and this was used to estimate the hourly traffic density. Traffic count was conducted three times a day, morning, afternoon and evening.

## Results and Discussion

### Fuel wise composition

The percentage composition of the fuel has calculated and it has been estimated that petrol contributes 63% followed by diesel and CNG 27% and 10% respectively.

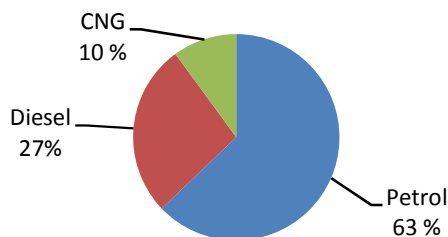


Figure 2. Fuel Composition

### Air Pollutant Composition

Air Pollutant NO at Okhla Subzi Mandi shows both a slightly increase and decrease. When analysing the percentage distribution of the above-said pollutants, we see that  $\text{NO}_x$  contributing the highest percentage of 45% followed by  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{SO}_2$ ,  $\text{O}_3$ ,  $\text{CO}$  having 26%, 19%, 9%, 1% and 0% respectively.

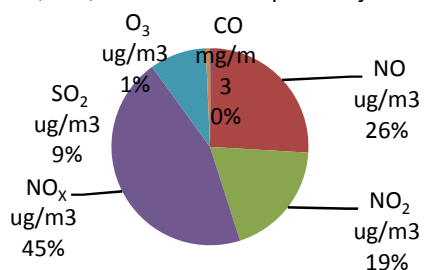


Figure 3. Percentage of Air Pollutant at Okhla Subzi Mandi

### Traffic Composition

From the composition of traffic showing in Figure, the traffic is dominated by cars by 40% followed by 2-wheelers by 33%, buses by 3%, 3-wheelers by 14%, LCV by 4%, HCV by 3% and Auto goods by 3%.

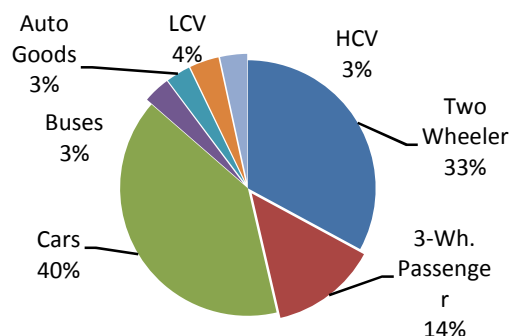


Fig.4: Traffic Composition at Okhla Subzi Mandi

### Noise Measurement

The sound-pressure level data were recorded in both peak and non-peak traffic hours which were used to compute equivalent continuous sound pressure level for one hour duration ( $\text{Leq}(1\text{hr})$ ), lowest root mean squared sound pressure level within the measuring period ( $\text{Lmin}$ ), highest root mean squared sound pressure level within the measuring period ( $\text{Lmax}$ ). The measured noise levels exceeded for 10% of the time of the measurement duration ( $\text{L10}$ ), 50% of the time of the measurement duration ( $\text{L50}$ ), and 90% of the time of the measurement duration ( $\text{L90}$ ) were also determined.

Table 1. Noise level measurement with time period

Time (hrs.)	L10	L50	L90	Leq	Lmax	Lmin
08.00-09.00	79	73	65	79	108	97
09.00-10.00	78	71	63	80	108	92
10.00-11.00	77	70	61	80	106	90
11.00-12.00	77	70	61	80	103	95
12.00-13.00	77	67	61	80	125	98
13.00-14.00	76	70	64	79	125	98
14.00-15.00	79	73	69	79	112	102
15.00-16.00	80	74	70	79	112	102
16.00-17.00	80	75	71	79	112	103
17.00-18.00	82	76	72	80	113	104
18.00-19.00	82	77	72	80	124	107
19.00-20.00	82	77	72	80	124	107
20.00-21.00	82	77	72	81	124	107
21.00-22.00	82	77	72	81	124	107
22.00-23.00	81	74	74	79	98	87
23.00-24.00	83	78	74	75	99	88
00.00-01.00	82	76	72	74	100	88

01:00-02:00	83	77	73	74	114	103
02:00-03:00	83	77	73	73	114	103
03:00-04:00	82	77	73	73	114	103
04:00-05:00	83	77	73	74	116	107
05:00-06:00	83	77	73	73	110	100
06:00-07:00	81	76	72	77	110	101
07:00-08:00	80	73	69	77	110	99

### Correlation between Traffic and Air Pollutant:

To better understand the relation between different air pollutants, traffic, noise and meteorology, the correlation were found. The Pearson's correlation values between fuel types (petrol, diesel and CNG) and air parameters (CO, NO, NO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, and O<sub>3</sub>) are calculated using SPSS at Okhla Subzi Mandi. Values for petrol and air pollutants are: -0.035, -0.713, -0.569, -0.672, 0.308, -0.672; diesel: -0.160, -0.660, -0.462, -0.601, 0.419, -0.521; CNG: 0.204, -0.808, -0.695, -0.778, 0.255, -0.626. The correlation between CNG and air parameters was relatively higher than that for Petrol and least correlation is observed for diesel. However, the highest correlation for CNG and Petrol is given by SO<sub>2</sub> followed by NO, NO<sub>2</sub>, O<sub>3</sub>, NO<sub>x</sub>, and CO. For diesel, the trend of correlation is SO<sub>2</sub>, NO, NO<sub>2</sub>, O<sub>3</sub>, NO<sub>x</sub> and CO.

Correlations

	CO	NO	NOX	NO2	SO2	O3	petrol	Diesel	CNG
CO Pearson Cor	1	.204	.262	.225	.159	.071	-.035	-.160	-.204
Sig. (2-tailed)		.349	.227	.303	.468	.747	.875	.465	.351
N	23	23	23	23	23	23	23	23	23
NO Pearson Cor	.204	1	.964*	.996*	.223	.798*	-.713*	-.660*	-.808*
Sig. (2-tailed)	.349		.000	.000	.306	.000	.000	.001	.000
N	23	23	23	23	23	23	23	23	23
NOX Pearson Cor	.262	.964*	1	.984*	.428*	.767*	-.569*	-.462*	-.695*
Sig. (2-tailed)	.227	.000		.000	.042	.000	.005	.026	.000
N	23	23	23	23	23	23	23	23	23
NO2 Pearson Cor	.225	.996*	.984*	1	.292	.794*	-.672*	-.601*	-.778*
Sig. (2-tailed)	.303	.000	.000		.177	.000	.000	.002	.000
N	23	23	23	23	23	23	23	23	23
SO2 Pearson Cor	.159	.223	.428*	.292	1	.341	.308	.419*	.255
Sig. (2-tailed)	.468	.306	.042	.177		.112	.152	.047	.240
N	23	23	23	23	23	23	23	23	23
O3 Pearson Cor	.071	.798*	.767*	.794*	.341	1	-.672*	-.521*	-.626*
Sig. (2-tailed)	.747	.000	.000	.000	.112		.000	.011	.001
N	23	23	23	23	23	23	23	23	23
petro Pearson Cor	-.035	-.713*	-.569*	-.672*	.308	-.672*	1	.794*	.939*
Sig. (2-tailed)	.875	.000	.005	.000	.152	.000		.000	.000
N	23	23	23	23	23	23	23	23	23
Diest Pearson Cor	-.160	-.660*	-.462*	-.601*	.419*	-.521*	.794*	1	.776*
Sig. (2-tailed)	.465	.001	.026	.002	.047	.011	.000		.000
N	23	23	23	23	23	23	23	23	23
CNG Pearson Cor	-.204	-.808*	-.695*	-.778*	.255	-.626*	.939*	.776*	1
Sig. (2-tailed)	.351	.000	.000	.000	.240	.001	.000	.000	
N	23	23	23	23	23	23	23	23	23

\*Correlation is significant at the 0.01 level (2-tailed).

\*Correlation is significant at the 0.05 level (2-tailed).

### Air and Meteorology

Similarly, correlations between meteorology and air parameters were calculated to find the pearson's values at 0.01 and 0.05 levels of significance. Values observed are as follows: wind speed: -0.193, -0.430, -0.420, -0.419, -0.493, 0.108; wind direction: 0.090, 0.238, 0.303, 0.277, 0.091, -0.024; temperature: 0.285, 0.797, 0.884, 0.864, 0.910, 0.100; relative humidity: -0.285, -0.820, -0.868, -0.860, -0.907, -0.044. With air parameters, temperature and relative humidity shows the highest correlation followed by wind speed and wind direction. The trend of correlation for temperature and relative humidity is SO<sub>2</sub>, NO<sub>2</sub>, NO<sub>x</sub>, NO, CO, O<sub>3</sub>; for wind speed: SO<sub>2</sub>, NO, NO<sub>2</sub>, NO<sub>x</sub>, CO, O<sub>3</sub>; Wind Direction: NO<sub>2</sub>, NO<sub>x</sub>, NO, SO<sub>2</sub>, CO, O<sub>3</sub>.

Correlations

		CO	NO	NO2	NOX	SO2	O3	WS	WD	AT	RH
CO	Pearson Correlation	1	.204	.262	.225	.159	.071	.362	-.359	-.617**	-.149
	Sig. (2-tailed)		.349	.227	.303	.468	.747	.089	.093	.002	.497
	N	23	23	23	23	23	23	23	23	23	23
NO	Pearson Correlation	.204	1	.964**	.996**	.223	.798**	.267	-.518*	.093	.744**
	Sig. (2-tailed)	.349		.000	.000	.306	.000	.217	.011	.671	.000
	N	23	23	23	23	23	23	23	23	23	23
NO2	Pearson Correlation	.262	.964**	1	.984**	.428*	.767**	.177	-.377	.189	.753**
	Sig. (2-tailed)	.227	.000		.000	.042	.000	.419	.076	.387	.000
	N	23	23	23	23	23	23	23	23	23	23
NOX	Pearson Correlation	.225	.996**	.984**	1	.292	.794**	.240	-.477**	.125	.753**
	Sig. (2-tailed)	.303	.000	.000		.177	.000	.270	.021	.569	.000
	N	23	23	23	23	23	23	23	23	23	23
SO2	Pearson Correlation	.159	.223	.428*	.292	1	.341	-.046	.401	.382	.141
	Sig. (2-tailed)	.468	.306	.042	.177		.112	.837	.058	.072	.520
	N	23	23	23	23	23	23	23	23	23	23
O3	Pearson Correlation	.071	.798**	.767**	.794**	.341	1	.357	-.160	.261	.557**
	Sig. (2-tailed)	.747	.000	.000	.000	.112		.094	.466	.230	.006
	N	23	23	23	23	23	23	23	23	23	23
WS	Pearson Correlation	.362	.267	.177	.240	-.046	.357	1	-.286	-.373	-.046
	Sig. (2-tailed)	.089	.217	.419	.270	.837	.094		.186	.079	.836
	N	23	23	23	23	23	23	23	23	23	23
WD	Pearson Correlation	-.359	-.518*	-.377	-.477**	.401	-.160	-.286	1	.600**	-.239
	Sig. (2-tailed)	.093	.011	.076	.021	.058	.466	.186		.002	.273
	N	23	23	23	23	23	23	23	23	23	23
AT	Pearson Correlation	-.617**	.093	.189	.125	.382	.261	-.373	.600**	1	.477*
	Sig. (2-tailed)	.002	.671	.387	.569	.072	.230	.079	.002		.021
	N	23	23	23	23	23	23	23	23	23	23
RH	Pearson Correlation	-.149	.744**	.753**	.753**	.141	.557**	-.046	-.239	.477*	1
	Sig. (2-tailed)	.497	.000	.000	.000	.520	.006	.836	.273	.021	
	N	23	23	23	23	23	23	23	23	23	23

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).

### 5.3 Noise and Traffic

Values of correlation between traffic (motorised vehicles, buses and goods vehicles) and noise level ( $L_{10}$ ,  $L_{50}$ ,  $L_{90}$ ,  $L_{eq}$ ,  $L_{max}$ ,  $L_{min}$ ) are as follows: with Two wheelers:  $L_{10}$ : -0.449,  $L_{50}$ : -0.350,  $L_{90}$ : -0.397,  $L_{eq}$ : 0.850; Three wheelers: :  $L_{10}$ : -0.571,  $L_{50}$ : -0.437,  $L_{90}$ : -0.516,  $L_{eq}$ : 0.814; Cars:  $L_{10}$ : -0.485,  $L_{50}$ : -0.391,  $L_{90}$ : -0.437,  $L_{eq}$ : 0.877; Buses:  $L_{10}$ : -0.648,  $L_{50}$ : -0.548,  $L_{90}$ : -0.532,  $L_{eq}$ : 0.809; Auto goods:  $L_{10}$ : -0.471,  $L_{50}$ : -0.433,  $L_{90}$ : -0.262,  $L_{eq}$ : 0.399; LCV:  $L_{10}$ : -0.065,  $L_{50}$ : -0.075,  $L_{90}$ : 0.135,  $L_{eq}$ : 0.010; HCV:  $L_{10}$ : -0.462,  $L_{50}$ : -0.378,  $L_{90}$ : 0.532,  $L_{eq}$ : -0.663.

Correlations

		TwoWheeler	ThreeWheeler	Car	Bus	AutoGoods	LCV	HCV	L10	L50	L90	Leq	Lmin	Lmax
TwoWheeler	Pearson Correlation	1	.955**	.942**	.760**	.475*	.002	-.599**	-.449*	-.350	-.397	.850**	.446*	.265
	Sig. (2-tailed)		.000	.000	.000	.019	.994	.002	.028	.093	.055	.000	.029	.210
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
ThreeWheeler	Pearson Correlation	.955**	1	.925**	.792**	.582**	.081	-.552**	-.571**	-.496*	-.516**	.814**	.383	.164
	Sig. (2-tailed)	.000		.000	.000	.003	.708	.005	.004	.014	.010	.000	.065	.444
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
Car	Pearson Correlation	.942**	.925**	1	.712**	.438*	.038	-.564**	-.485*	-.391	-.437*	.877**	.466*	.173
	Sig. (2-tailed)	.000	.000		.000	.032	.862	.004	.016	.059	.033	.000	.022	.418
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
Bus	Pearson Correlation	.760**	.792**	.712**	1	.546**	-.074	-.734**	-.648**	-.548**	-.532**	.809**	.148	.043
	Sig. (2-tailed)	.000	.000	.000		.006	.731	.000	.001	.006	.007	.000	.491	.843
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
AutoGoods	Pearson Correlation	.475*	.582**	.438*	.546**	1	.622**	-.059	-.471*	-.433*	-.262	.399	.187	.117
	Sig. (2-tailed)	.019	.003	.032	.006		.001	.783	.020	.035	.216	.053	.382	.588
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
LCV	Pearson Correlation	.002	.081	.038	-.074	.622**	1	.581**	-.065	-.075	.135	.010	-.021	-.108
	Sig. (2-tailed)	.994	.708	.862	.731	.001		.003	.762	.729	.530	.965	.922	.616
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
HCV	Pearson Correlation	-.599**	-.552**	-.564**	-.734**	-.059	.581**	1	.462*	.378	.532**	-.663**	-.391	-.288
	Sig. (2-tailed)	.002	.005	.004	.000	.783	.003		.023	.069	.008	.000	.059	.173
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
L10	Pearson Correlation	-.449*	-.571**	-.485*	-.648**	-.471*	-.065	.462*	1	.954**	.931**	-.557**	-.007	.359
	Sig. (2-tailed)	.028	.004	.016	.001	.020	.762	.023		.000	.000	.005	.975	.085
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
L50	Pearson Correlation	-.350	-.496*	-.391	-.548**	-.433*	-.075	.378	.954**	1	.931**	-.474*	.027	.415*
	Sig. (2-tailed)	.093	.014	.059	.006	.035	.729	.069	.000		.000	.019	.900	.044
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
L90	Pearson Correlation	-.397	-.516**	-.437*	-.532**	-.262	.135	.532**	.931**	.931**	1	-.493*	-.021	.336
	Sig. (2-tailed)	.055	.010	.033	.007	.216	.530	.008	.000	.000		.014	.924	.108
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
Leq	Pearson Correlation	.850**	.814**	.877**	.809**	.399	.010	-.663**	-.557**	-.474*	-.493*	1	.306	.066
	Sig. (2-tailed)	.000	.000	.000	.000	.053	.965	.000	.005	.019	.014		.146	.758
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
Lmin	Pearson Correlation	.446*	.383	.466*	.148	.187	-.021	-.391	-.007	.027	-.021	.306	1	.784**
	Sig. (2-tailed)	.029	.065	.022	.491	.382	.922	.059	.975	.900	.924	.146		.000
	N	24	24	24	24	24	24	24	24	24	24	24	24	24
Lmax	Pearson Correlation	.265	.164	.173	.043	.117	-.108	-.288	.359	.415*	.336	.066	.784**	1
	Sig. (2-tailed)	.210	.444	.418	.843	.588	.616	.173	.085	.044	.108	.758	.000	
	N	24	24	24	24	24	24	24	24	24	24	24	24	24

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).



## Conclusion

This paper presents the hourly variation of different air pollutants, meteorological parameters, sound pressure level data and traffic density and correlation between Air Pollution, Traffic, Noise and Meteorology at a selected location in Delhi. The study was conducted at Okhla Subzi Mandi during the month of February, 2013 and the analysis of 24 hours average values were done for the period of 24 hours. The main aim of this study is to correlate the four variable parameters - air pollution, vehicular traffic, noise and meteorology, considered at three selected in Delhi. Pearson's correlations calculated between three categories are: air and traffic; air and meteorology; air and traffic; and noise and traffic.

The fuel wise composition of traffic indicates that the percentage composition of Petrol is highest followed by diesel and CNG. This is due to the fact that the use of Petrol fuel is higher in Delhi as compared to other fuels.

The following air pollution parameters CO, NO, NO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub> and O<sub>3</sub> were observed at Okhla Subzi Mandi in Delhi for a period of 1 day. Observation shows a much decrease in SO<sub>2</sub> parameter and high increase in NO, NO<sub>2</sub>, and NO<sub>x</sub> parameters from their standard. While NO<sub>2</sub> shows both a slightly increase and decrease. When analysing the percentage distribution of the above-said pollutants at

Okhla SubziMandi, we see that NO<sub>x</sub> contributing the highest percentage of 45% followed by NO, NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, CO having 26%, 19%, 9%, 1% and 0% respectively.

It is noticeable that the major part of the population is exposed to noise levels greater than 65 dBA everyday, considered by preventive medicine as the limit value one can exposed to. A widely accepted scientific fact is that the living in area with the Leq higher than 65 dBA put an urban population in a high risk category for numerous noise subjective effects, including psychological, sleep, and behavioural disorders. However many useful work has been done to mitigate the noise problem, rapid growth of vehicle fleet during the recent years causes to remain the problem persistently. Old car manufacturing technology, traffic jam and lack of modern traffic control equipments and planning along with lack of strong police monitoring are the major reasons of noise pollution in the city. The developing of dense green trees at both sides of streets is recommended. Noise level abatement by promote the maintenance of public vehicles, control of vehicle noise emission by policemen and broadcast of the noise emission standards for car manufacturing company are the other possible activities may reduce the noise level in the city.

## References

- Bertaccini P, Dukic V& Ignaccolo R [2012] Modeling the Short-Term Effect of Traffic and Meteorology on Air Pollution in Turin with Generalised Additive Models, vol:12, Article ID 609328; DOI:10.1155/2012/609328.
- Biswas J, Upadhyay E, Nayak M & Yadav AK [2011] An Analysis of Ambient Air Quality Conditions over Delhi, India from 2004 to 2009. *Atmos. Clim. Sci.* 1: 214–224.
- Bhuyan PK, Samantray P & Rout SP [2010] Ambient air quality status in Choudwar area of Cuttack District, *International Journal of Environmental Sc.* 1(3): 343-356
- Eiman K [2009] A Real-Time Mobile Phone Platform for Urban Noise Monitoring and Mapping , Springer doi 10.1007/s11036-009-0217-y.
- Chow JC & Watson JG [2011] Air quality management of multiple Pollutants and multiple effects. *Air Quality and Climate Change Volume 45 :3*(2011).
- Kaushik I & Rinki M [2007] Time series analysis of ambient air Quality at ito intersection in delhi" *Journal of Environmental Research and Development Vol. 2* : 2.
- Shukla V, Dalal P & Chaudhry D [2010] "Impact of vehicular exhaust on ambient air quality of Rohtak city, India" 31(6) : 929-932.
- Hedgecock W, Völgyesi P, Ledeczki A, Koutsoukos X, Aldroubi A, Szalay A & Terzis A [2010] Mobile Air Pollution Monitoring Network SAC'10 March 22-26, 2010, Sierre, Switzerland.
- Xianglu H & Luke P [2005] A review of Traffic-related air Pollutant Exposure assessment studies in developing world. *Environment International*, 32(1):106-120.

**IJENAS****International Journal of Environment and Natural Sciences**Website: [www.ijenas.com](http://www.ijenas.com); Email: [journalijenas@gmail.com](mailto:journalijenas@gmail.com); © Centre for research in ecology, environment and social sciences (CREES)

ISSN: 2349-3763

# Isolation of Oil Degrading Bacteria from Soil and Bioremediation under In-situ Conditions

Chaitra Nayak<sup>1\*</sup> & Sonali Joshi<sup>2</sup>

<sup>1</sup>Department of Environmental Sciences, Fergusson College Pune, INDIA

<sup>2</sup>Head of Department of Biotechnology, Fergusson College, Pune, INDIA

\*Corresponding author's E-mail: [chaitra1991@gmail.com](mailto:chaitra1991@gmail.com)

(Received: October 15, 2014; Accepted 20, 2014)

## Abstract

This study has been planned along the lines of findings that indicate garage spills have serious environmental implications, towards which developing a bioremediation protocol that could be exploited for cleaning oil polluted soil was the objective. This study addresses the concern of the environmental impact of petroleum hydrocarbons on soils that have been subject to oil spillages surrounding automotive garages. Petroleum hydrocarbons which make up oil components are the contaminants that degrade over time because of the indigenous microbial flora and these form the basis of bio-augmentative bioremediation. Towards these goals, isolation and degradation studies, gravimetric analysis and enzyme roles have been analyzed. Screening of soil samples obtained three species a yeast and two bacterial species. These were tested each individually for degradation, along with consortia of all three *in-situ*, to give a maximum degradation of 9.016% over the span of four weeks. Upon studying enzyme roles it was found that extracellular enzymes assist the microbes metabolic activities of degradation in most cases.

**Keywords:** Biodegradation, hydrocarbons, microorganisms, bioaugmentation, gravimetry, extracellular enzymes.

## Introduction

Oil spillage on land accounts for majority of the hydrocarbon contamination on our planet (Hamaiedh & Maaitah, 2010). Oil spillage has become inevitable considering the industrialization rates along with development which involves activity that transports, refines, processes & other routine operations in crude oil production & usage (Das & Chandran, 2010) although major focus have been on marine oil spills, soil pollution due to garages or automotive repair centers are equally disastrous.

Garages and service centers carry out a number of operations and processes that have the potential to damage the environment. These include the dewaxing and cleaning of vehicles, the storage, use and disposal of

polluting liquids such as oils, paints, solvents, antifreeze and other coolant additives, brake fluids and solid waste such as oil filters, exhaust systems, batteries and tyres. Unless the site drainage is correct, waste is properly managed and spillage control procedures are in place, environmental harm could occur. (Sempebwaa & Carpenter, 2012). Soil pollution by different oil products is a serious geo-environmental problem that adversely affects the quality of soil, groundwater and the atmosphere. When oil products accidentally spill over the ground surface, it infiltrates through the unsaturated zone where part of it is retained in this zone, while the other part reaches the water table causing ground water pollution. Evaporation of the retained part to



the atmosphere pollutes the air, vegetation, and has a deleterious effect on human beings (Pandey & Bind, 2014) Direct land usage in this way can contribute to such a pattern of soil contamination.

Among several clean-up techniques available to remove petroleum hydrocarbons from the soil and groundwater, bioremediation processes are gaining ground due to their simplicity, safety, higher efficiency and cost-effectiveness when compared to other technologies. (Teli et al., 2013) This study was therefore designed to monitor the rate of biodegradation of engine oil (hydrocarbon) by microorganisms isolated from garage soil (petroleum contaminated soil) by using gravimetric method. (Latha & Kalaivani, 2012). This natural degradation process happens over a span of time, to increase the rate of biodegradation is one of the purposes of the study. In that respect isolation of the strains that tolerated 1% oil were selected. The three most dominant ones were tested for tolerance

and degradation capabilities. The isolates were then routinely identified using an automated system called VITEK.

Following which an in-situ study of different strains along with a mixed consortium (Mandal et al., 2012; Vasudevan & Rajaram, 2001) was tested in laboratory scale composters under uniform conditions of moisture and aeration. The composters were supplemented in such a way that the bioavailability of the hydrocarbon introduced was appropriate, which is often a limiting factor *ex situ*. (Singh & Lin, 2008; Vamsi & Garapati, 2012)

This study examines which of the microbial enzyme systems enhance the rate of biodegradation of petroleum hydrocarbons by extracting enzymes from the isolated species (Barnabas et al., 2013; Yuan & Krishnamurthy, 1995) In addition the study evaluates the future prospects of enzyme assisted bioremediation.

## Materials and methods

### 1. Isolation studies and subsequent characterization

For the isolation of diesel bacterial degraders, four garages were selected as locations around the areas of F.C road and Karvenagar. In these areas activities that routinely occurred and contributed to spillages were observed, heavy contaminations were observed in all the garages. Sample collection was carried out at the depth of 15 cm where soil was dug out and placed immediately in polythene bags, hence four samples were collected. After being labeled they were stored at 4 degrees to prevent external microbiological influences. In this way a subsurface sample of oil contaminated soil was collected from four different areas

For the Isolation studies the hydrocarbon contaminated soil collected from various garages were screened for dominant microorganisms. Soil (1gm) from each source was suspended and vortexed along with 10ml of distilled water. The suspension was allowed to settle down and 5 ml of the supernatant was used as inoculum in Luria Bertini Broth (LB) prepared Erlenmeyer flasks. Autoclaving guaranteed a sterile media preparation. A Control and 4 flasks of each of the samples along with 1% oil were incubated under shaker conditions at 100rpm for a period of 48 hours.

Control: 100 ml LB Broth +1ml spent oil

Test: 4 x 100 ml LB Broth + 1ml spent oil + 5ml supernatant of vortexed soil sample.

- After a period of 48 hours the flasks were then used as primary culture. Autoclaved LB Oil Agar medium (3% Agar, 1% Oil ) was dispensed in petriplates and allowed to solidify then using spread and 5 way streak techniques each of the samples were plated. These plates were incubated at room temperature for 24 hours. As oil was the only carbon source (Li G et al 2000) selective enrichment of oil degrading organisms could be achieved. Those organisms those were able to use oil as a carbon source would be able to grow.
- At the end of 24 hours dominant colonies obtained were further streaked on petroleum agar plates to obtain pure culture of enriched organisms.
- The colony characteristics of the isolates were noted down. Gram staining and motility studies were performed. The isolates were transferred on nutrient agar slants and preserved at 4 degrees.

For characterization, of the isolated cultures VITEK, an automated technology developed by Biomerieux with a view to fulfill the need for fast accurate microbial identification. It consists of VITEK cards (a new generation

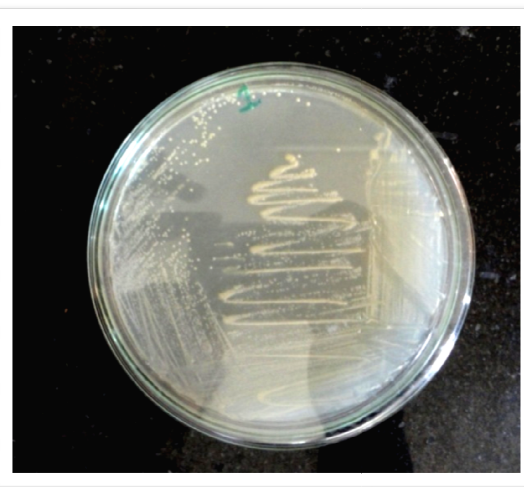
test card) where, isolates are inoculated with high speed. These isolates go through a database of tests which eliminate biochemical manual testing for identification purposes and give accurate results within 16-18 hours

## 2. Analysis of soil used for bioremediation

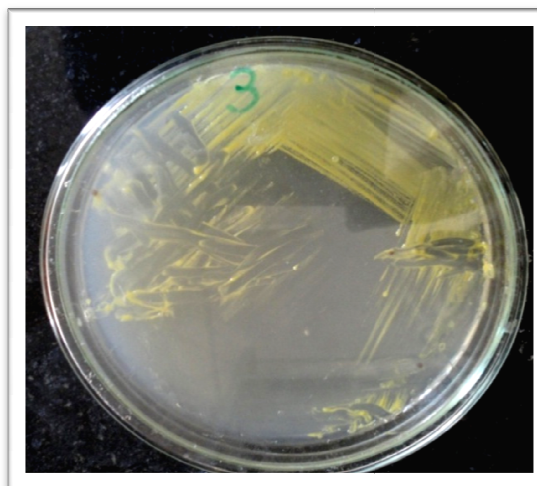
For the analysis of the soil obtained from the garages fresh uncontaminated soil with no prior history of contamination was used for bioremediation purposes. The following parameters of soil were analyzed using standard techniques for the basic parameters, that is pH, hardness, calcium & magnesium, phosphorous, organic carbon and dry solids fraction.

## 3. In situ bioremediation and gravimetric analysis

The previously analyzed soil to be used was sieved for removing stones and pebbles. The experimental set up included the use of four lab scale plastic containers each filled with 400g of soil. The three composters were inoculated with the three isolates 1, 3 and 4 (Figure 1) while the fourth was inoculated with mixture of 1, 3 and 4 and denoted as M ( $3 \times 10^8$  cells per ml).



**Figure 2.** Isolate 3 as observed on petroleum (1%) infused LB agar



**Figure 1.** Isolate 1 as observed on petroleum (1%) infused LB agar

5 ml of 2T engine oil was added to each of the composters. (Flash point 70 degrees C/min). Grass (2gm in each composter) was used as the bulking agent, (Namkoong, Hwang, Park and Choi J Y, 2002) (Jorgensen, Puustinen and Suortti 2000) it prevents the creation of anoxic conditions (Rhykerd, Crews, McInnes and Weaver 1999) and thus preventing the bioremediation set up to become unviable which would result in a collapse in the degradation pattern.

Each of the composters was adjusted to have a cell density of  $3 \times 10^8$  (McFarland standard no.1) using McFarland's Nephelometry Standards respectively with isolates 1, 3, 4 & M (Figure 2) (M signifies a mixture of isolates 1, 3 and 4).

McFarland Nephelometer Standards are as follows: (Farland & Jama, 1907)

McFarland Standard No.	0.5	1	2	3	4
1.0% Barium chloride (ml)	0.05	0.1	0.2	0.3	0.4
1.0% Sulfuric acid (ml)	9.95	9.9	9.8	9.7	9.6
Approx. cell density ( $1 \times 10^8$ CFU/mL)	1.5	3.0	6.0	9.0	12.0
% Transmittance*	74.3	55.6	35.6	26.4	21.5
Absorbance*	0.08 to 0.1	0.257	0.451	0.582	0.669

\*at wavelength 600 nm

This setup was covered with a gauze cloth to prevent insects and other unwanted disturbance, also to facilitate aeration. At frequent intervals water was added to the composter to maintain an average moisture level. (Gestel, Mergaert, Swings, Coosemans and Ryckeboer 2003) Drying up of the soil would result in the culture not surviving and ultimately a failure in the bioremediation process. The soil was also mixed thoroughly every alternate day.

Gravimetric analysis:

- The compost matrices were analyzed for oil and grease using Soxhlet Extraction method 5520 D (APHA, 1985). Weekly analysis of the composters starting from week 0 onwards was carried out.
- The Extraction flask of the Rotary evaporator flask was weighed. Each week 8gm of the soil sample from each composter 1, 3, 4 and M was subject to gravimetric analysis using Soxhlet extraction principles.
- In this procedure Rotary evaporator at 80°C at 30 rpm until the extraction solvent mixture which was 80% n-Hexane/20% Methyl-Tert Butyl Ether v/v, was completely evaporated. Rotation ensures homogenous mixing of the sample and prevents overheating inside the flask.
- Vacuum was applied along appropriate intervals to facilitate a complete extraction of oil from the contaminated soil. Vacuum is used to lower the boiling temperature and hence raise the efficiency of the distillation process.
- After complete evaporation the Extraction flask was weighed again.

#### 4. Extraction of Enzymes and their study

Pure culture of the 3 isolates and the consortia was inoculated into petroleum broth media in a flask containing 100ml of petroleum broth

media and 100µl of petroleum oil and incubated for 48 hrs.

The composition of 500 ml Petroleum Broth is as follows: Beef Extract (1.5gm) Peptone (2.5gm) Sodium Chloride (2.5gm) D/W (500 ml) Oil (500ul)

- After incubation for 48 hours, 3000µl of broth was removed without any oil traces by using a micropipette from the 4 flasks and collected in tubes. The collected broth was subjected to centrifugation at 5000 rpm for 10 minutes to separate extracellular enzyme. The supernatant containing a layer of solution that contains extracellular enzyme was collected.
- After this procedure 30ml of the Petroleum broth was subject to sonication using a sonicator for 1 min each. Sonication causes cell disintegration.
- Further the broth was cold centrifuged at 8000 rpm at 4°C for 30 min based on the principle of sedimentation, in such a way that the supernatant would contain intracellular enzyme. The cold temperature allows a constant operation temperature and allows temperature sensitive material to stay intact.

#### 5. Detection of Enzymes using Filter paper Disc Method

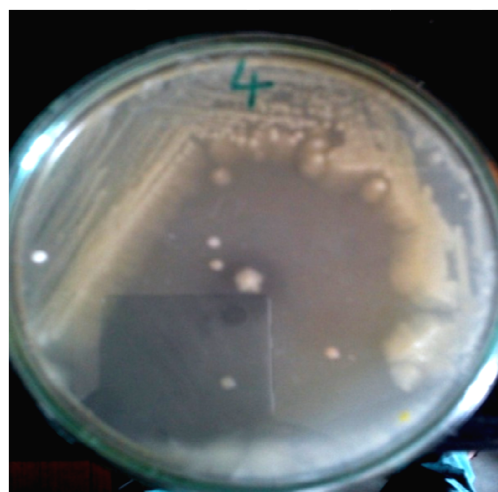
In order to detect the enzyme, which we hypothesized, that is responsible for enhancing degradation or utilization of garage oil, enzymes were used (extracellular, intracellular and extracellular + intracellular) extracted from each of the isolates. For the detection of enzymatic effect; petroleum agar plates were prepared, then enzyme extract was added into the plates after solidification.

Filter paper discs were cut into small circular disc shape and sterilized. The Filter paper discs were kept dry during sterilization by placing in a petriplate. Three formulations of

enzyme extract were used to detect which of them enhanced the bioremediation process they were:

1. Extracellular enzyme (10 $\mu$ l)
2. Intracellular enzyme (10 $\mu$ l)
3. Combination of intracellular and extracellular enzyme (20 $\mu$ l)

10 $\mu$ l of enzyme extract (extracellular, intracellular or extracellular + intracellular) was added on the disc and placed on the plate in a triangle format with petroleum oil agar media previously inoculated with pure culture by spread plate technique and these plates were incubated at 37 °C for 24 hours.



**Figure 3.** Isolate 4 as observed on petroleum (1%) infused LB agar

## Results and discussion

The soils typically contain  $10^9$  to  $10^{10}$  microorganisms per gram (dry weight), which may represent more than a million bacterial species. Primary isolation in LB broth infused with petroleum after an incubation of 48 hrs showed turbidity in all four flasks. The Control showed no such turbidity. Hence Primary enrichment was successful. A mixed culture from each of the soil sample was obtained. Frothing of the oil was observed along the sides of the flask because of the applied shaker conditions. An aliquot from each of these flasks were then used to prepare streak

& spread plates using aseptic techniques. Sterile LB agar infused with 1% oil was the enrichment culture media.

All the plates showed a mixed culture. Even hyphae of fungi were prominent. The dominant colonies were selected and these individual colonies of bacteria which varied in shape and color were picked up and streaked.

After the 24 hours the isolated culture grew the colony characters of the three isolates were mentioned in Table 1.

**Table 1.** Colony Characters of Isolated spp as observed on LB agar oil infused plates

Isolate no	Size (mm)	Shape	Margin	Elevation	Surface Density	Pigment/Odour	Gram Nature
1	13-17	hyphae	entire	raised	smooth	-	-
3	2	circular	entire	convex	smooth	yellow	Gram Positive
4	6-7	circular	irregular	raised	wrinkly	earthy	Gram Positive

The isolates 1, 3 and 4 grown on McConkeys Agar and were sent to a clinical lab for testing using VITEK cards, (Figure 3).

The Organisms were identified as

1. *Trichosporon mucoides*

Analysis time: 18.25 hours

Bionumber

:6376777177377571

2. *Micrococcus luteus/lylae*

Analysis time: 6.00 hours

Bio number:

041032300000000

The isolate no.4 could not be revived from its slant hence remains unidentified.

Generally, a decrease in oil levels was observed although in Composter 1 in week no. 3 an increase was observed this may have been due to an error in extraction procedure. This rate of decrease was used as an index to monitor the progress of biodegradation.

Maximum oil was degraded between weeks 2 and 3.

Oil removal rates were measured using the formula:

Oil & grease as % of dry solids

= Gain in weight of flask (g) x 100/Weight of wet solids (g) x dry solids

After a period of 4 weeks the composter M containing a consortium showed the maximum degradation of 9.016 %. Thus, a consortium with broad enzymatic capacity is more effective in degrading complexes of hydrocarbons in soil.

The enzymes were extracted using the above mentioned procedures and extracts added with the help of micropipettes on plates named as 1, 3, 4 and M.

Triangular formation of filter paper discs on which enzyme extracts were added after incubation showed variation in cfu (colony forming units) around each filter paper disc

It was conceptualized to detect the enzyme type which enhances in degrading/utilizing oil, which is by considering the density of

microbial growth around the region where a particular enzyme was added (extracellular enzyme or intracellular enzyme or the mixture of equal amount of the both enzymes), and to estimate Colony Forming Units (CFUs) for the effect of added enzyme (Extracellular or Intracellular or mixture of both) in agar plate. Due to effect of added enzyme, bacterial cells tend to grow enhanced and therefore colony density would be thicker around particular added enzyme extract.

On the basis of this principle highest CFUs were observed in the agar plate with added extracellular enzyme of culture 1, culture 4 and the mixed culture.

In the plate with culture *Micrococcus luteus* the mixture of enzymes showed maximum CFU. (Tables 2, 3, 4).

**Table 2.** Standard soil parameters of soil used in the composters for carrying out bioremediation

Soil Parameters	
pH	8.21
Hardness	Not detectable
Calcium	3.126 mg/L
Magnesium	Not detectable
Phosphorous	86 ppm
Organic Carbon	0.39 %
Dry solids fraction(gm)	6.979

**Table 3.** Oil removal in composters at different weeks of incubation ( in %)

Week	Composter 1	Composter 3	Composter 4	Composter M
0	0	0	0	0
1	0.47	0.484	0.042	1.88
2	6.288	3.599	3.982	4.144
3	5.089	7.253	7.510	8.962
4	8.492	7.755	8.004	9.016

**Table 4.** Number of colonies observed around filter paper disc in enzyme assay by filter paper disc method .

Isolate number	Extracellular(e)	Intracellular(i)	Mixed(m)
1	52	13	46
3	25	15	36
4	46	10	25
M	59	7	34

## Conclusion

Upon isolation and subsequent identification of oil tolerant and degrading organisms it was found that one of them was a yeast species, *Trichosporon mucoides* while the other was a species of bacteria *Micrococcus luteus*.

Bioremediation of oil involve highly heterogeneous and complex processes. In this study a maximum degradation of 9.016% of oil was achieved in the Composter which was inoculated with a consortia of the three isolated species this concludes that since a mixed culture would contain broader enzymatic capacities it is more ideal in a clean-up process, than typically using only large quantities of a single potential degrader.

Bioremediation is a relatively slow process and requires some weeks to months which may not be feasible when immediate cleanup is demanded, this is its primary disadvantage. Although a bioremediation protocol is designed in such a way that it acts in compatibility with nature, since there is no addition of substances that would further toxify or modify the environment as physical and chemical processes would.

Enzymatic study revealed that mainly the extracellular enzyme assists degradation of hydrocarbons, although in the species *Micrococcus luteus* both intracellular & extracellular enzymes had equivalent hydrocarbon breakdown roles.

## Acknowledgement



I would like to acknowledge the constant help provided by the Department of Biotechnology & Joshi Hospital of Maharashtra Medical Foundation, Deccan Pune towards the prompt completion of my project.

## References

- Al-Hamaiedh HD, Maaitah O [2010] Treatment of oil polluted soil using electrochemical method, *Alexandria Engineering Journal* 50(1):105–110
- APHA, AWWA, WPCP [1985] Standard Methods for the Examination of Water and Waste Water 16th Edn.
- Baker KH, Herson DS [1994] Bioremediation Comprehensive guide to bioremediation – introduction to the basic techniques and applications of Bioremediation, *McGraw-Hill* pp375
- Barnabas J, Saha S, Singh V, Das V [2013]. Effect of enzyme extracts on bacterial degradation of Garage petroleum. *Journal of Environmental Science, Computer Science and Engineering & Technology* 2(2): 206-211.
- Singh C, Lin. J [2008] Isolation and characterization of diesel oil-degrading indigenous microorganisms in KwaZulu-Natal. South Africa, *African Journal of Biotechnology* 7:1927-1932
- Das N, Chandran P [2010] Microbial Degradation of Petroleum: Hydrocarbon Contaminants .An overview *Biotechnol Res Int.* Article Id 941810.
- Fan Chi-Yuan & Krishnamurthy S [1995] Enzymes for Enhancing Bioremediation of Petroleum-Contaminated Soils: A Brief Review , *Journal of Air & Waste management association*.45(6):453-460
- Gestel K V, Mergaert J, Swings J, Coosemans J & Ryckeboer J [2003] Bioremediation of diesel oil-contaminated soil by composting with biowaste, *Environmental Pollution* 125 :361-368.
- Jorgensen K S, Puustinen J & Suortti A M, [2000] Bioremediation of petroleum hydrocarbon-contaminated soil by composting in biopiles, *Environmental Pollution*, pp 245-254
- McFarland J, Jama MD [1907] The Nephelometer: An Instrument For Estimating The Number of Bacteria In Suspensions Used For Calculating The Opsonic Index For Vaccines., *Journal of the American Medical Association*, 14: 1176-1178.
- Latha R, Kalaivani R [2012] Bacterial Degradation of Crude Oil by Gravimetric Analysis, *Advances in Applied Science Research*, 3 (5):2789-2795
- Li G., Huang W., Lerner DN, Zhang X [2000] Enrichment of degrading microbes and bioremediation of petrochemical contaminants in polluted soil. *Water Research* 34:3845-3853
- Mandal A K, Sarma P M, Singh B, Jeyaseelan C P, Channashettar V A, Lal B, Datta J. [2012] Bioremediation sustainable eco-friendly biotechnological solution for environmental pollution in oil industries. *ARPN Journal of Science and Technology* VOL. 2, Special Issue, ICESR 2012
- Mittal A and Singh P [2009] Isolation of hydrocarbon degrading bacteria from soils contaminated with crude oil spill. *Indian Journal of Experimental Biology* 47 :760-765
- Morasch B, Richnow H, Schink B, Vieth A, Rainer U. Meckenstock [2002]. Carbon and Hydrogen Stable Isotope Fractionation during Aerobic Bacterial Degradation of Aromatic Hydrocarbons *Appl Environ Microbiol* 68(10):5191-4.
- Namkoong W, Hwang E Y, Park J S & Choi J Y, [2002] Bioremediation of diesel contaminated soil with composting, *Environ Pollution* 9(1): 23-31.
- Pandey A and Bind YK, [2014] Effects of Oil Contamination on Geotechnical Properties of Alluvial Soil Naini, Allhabad *International Journal of Innovative Technology and Exploring Engineering* 2 (8) 39-42
- Rhykerd R L, Crews B, McInnes K J & Weaver R W, [1999] Impact of bulking agents, forced aeration and tillage on remediation of oil-contaminated soil, *Bioresour Technol* 67 (3) 279-285
- Ssempebwa J C and Carpenter D [2012] The generation use and disposal of waste crankcase oil in developing countries: A case for Kamapala district, Uganda. *Journal of hazardous materials*, 161(2-3), 835-41.
- Teli N, Verma D, Gavankar R, Bhalerao S [2013] Isolation, Characterization and Identification of Diesel Engine Oil Degrading Bacteria from Garage Soil and Comparison of their Bioremediation Potential *International Research Journal of Environment Sci.* Vol. 2 48-52
- Vamsi S, Garapati K [2012] Biodegradation of petroleum hydrocarbons. "http://ethesis.nitrkl.ac.in/ 4467/1/Vamsi\_Thesis.pdf"
- Vasudevan N, Rajaram P [2001] Bioremediation of oil sludge contaminated soil, *Environment International* 26(5) 409-411



# Women and Environment Conservation: An Overview

**Charu Joshi\* & Jyoti Upadhyay**

*Assam University, Silchar, Assam-788011, INDIA*

*\*Corresponding author's E-mail: [charu6@gmail.com](mailto:charu6@gmail.com)*

(Received: September 12, 2014; Accepted: September 19, 2014)

## Abstract

In Sanskrit women is expressed as Prakriti meaning Mother Nature or Earth. Women and environment relate to each other in many ways as women contribute in many ways for environmental upliftment and conservation. In their hands lie exceptionally extensive decisions about the use of community resources – water consumption for the household, land use for agriculture purpose, wood collect for heating and cooking, plants and animals for food and sale. But due to speedy changes in lifestyle and depleting natural resources women find themselves faraway from environment conservation and development. It thus becomes important to remember the key role played by women in the past and necessary steps should be taken in order to bring balance in the eco-system.

**Keywords:** *Women, Environment, Conservation, Sustainable Development, Eco-feminism and Biodiversity*

## Introduction

Human beings are at the center of concern for sustainable environmental conservation and protection. They are entitled to a healthy and productive life in harmony with the Mother Nature. Each and every thing on earth is dependent on Mother Nature for survival. It is said that if she is angry (little imbalance) brings catastrophe such as floods, droughts, tsunami etc. Thus it is essential for us to continue maintaining the balance with nature, as we are the most superior beings on planet earth.

Mother Nature indicates clearly that the women have direct connection with nature as women are the embodiment of the feminine principal at one hand and at another she is nurtured by the feminine to produce life and provide sustenance. (Shiva, 1988)

There is increasing evidence today that women in developing countries and especially those living in rural areas, tribal and ethnic people are considered as the primary users of natural resources (land, forest and water).

They are very close to the mother nature than men because they are the one's responsible for gathering food, fuel and fodder for their family, thus making them responsible managers for their own ecosystem. The life of mountain women is more extensively intertwined with their surrounding eco-system such that it revolves around her and she can't even think of her survival without it because since time immemorial, women have been traditionally involved in protecting and conserving their natural ecosystem in the form of natural resources. With their extraordinary skills and traditional knowledge, women have proved how land, water, forest and other available natural resources can be used and managed for sustainable survival. Through their practical experiences followed from generations to generations i.e. from mother to daughter they have acquired immense knowledge regarding types of plants, herbs, roots, trees, fruits, flowers, animal fodder, local species, ecosystems etc. They know better

what grass, herbs, shrubs, trees are best for them and should be planted and prefer a mixed forest, which can in the end meet their

### History behind women and environment

The relationships between women and environment extend far back into human history, when division of responsibilities was by gender as the man being hunter and women being collector. The survival of mankind has been due to much more 'woman-the-gatherer' than to 'man-the-hunter'. According to Lee and de Vore, in ancient world, women provided up to 80 per cent of the daily food, whereas men contributed only a

demands and also bring balance in the ecosystem.

small portion by hunting. Elizabeth Fisher's studies indicate that gathering of vegetable food was more important for our early ancestors than hunting. Finally, Maria Mies has argued that the relationship of man-the-hunter with nature was necessarily violent, destructive and predatory, in sharp contrast to the relationship that woman the-gatherer or cultivator had. (Shiva, 1988).

### Environmental movements and activities by women

Indian village women residing in the hills played an active role in giving birth to early environment movements. It was in the Garhwal region of Uttaranchal (Chamoli district), now known as Uttarakhand during the end of 1972 that the great Chipko Movement got its name and fame. Women of that province played a key role in igniting the fire to save their forest.

The iconic Chipko movement activists included village women, men and Gandhian activists. The movement was to stand against the commercial motives of the state government's to cut and sell trees. Women then came out of their houses led by Gauri Devi, who agitated, hugging trees and engaged in a confrontation with the contractors. The Chipko movement adopted the slogan 'ecology is permanent economy'.

The Chipko Movement brought forth the fact that the primary assets of the forests are soil, water and oxygen and not the timber as conventionally understood. Chipko movement is at the core a women's movement, for her families' survival. Thus, Eco-feminists around the world express Chipko movement as reactionary movement, which ended exploitation.

The obvious name behind Eco-feminism is Sherry Ortner. She coined the term 'Eco-feminism' in order to establish connection between women and nature. Ortner makes this connection to explain the universal subordination of women: 'Since it is always culture's project to subsume and transcend

nature,' and women are considered closer to nature due to their physiology, social roles, and psychic structure, 'then culture would find it 'natural' to subordinate, not to say oppress, them' (Ortner, 74). Ortner further says that the only way to escape this subordination is to completely take up the cultural 'projects of creativity and transcendence,' and also to completely align women with culture. Ecofeminism takes the women and nature connection a step further. (Jackson, 1993; Turner 2003)

Another important movement is Green Belt Movement (GBM) founded by Nobel Prize winner, Late Professor Wangari Maathai in Kenya during 1977. This movement was initiated in order to "respond to the needs of rural Kenyan women who reported that their streams were drying up, their food supply was less secure, and they had to walk further and further to get firewood for fuel and fencing. GBM encouraged the women to work together to grow seedlings and plant trees to bind the soil, store rainwater, provide food and firewood, and receive a small monetary token for their work." It aims to bring environmental restoration along with economic growth as well as empowering the rural women through environmental preservation, with a special emphasis on planting indigenous trees. GNB has planted over 51 million trees in Kenya. ([greenbeltmovement.org](http://greenbeltmovement.org)).

### Eco-feminism

As the world moves forward at a phenomenal speed with scientific and technological advances, there is a growing feeling that

environmental empowerment of women is absolutely essential for progress.

The link between women and environmental resources has been well documented. There is

for instance a growing body of literature on Eco-feminism, which seeks to combine different feminist theories and relates them to environmental issues. Ecofeminists explore gender oppression and environmental degradation, mainly caused by men, and hold that women have a responsibility to stop this male domination over both as the superior power treats all subordinates the same. Although Eco-feminism has not informed women's quest for access and control of natural resources. There is a school of thought that holds that the framing of the ecofeminist debate is so abstract that it ceases to be the grassroots movement that it ought to be. This school of thought considers the Women, Environment and Development (WED) movement as more relevant to women in developing countries (Braidotti et al., 1995). The WED approach postulates that women have an affinity to the environment and puts women as victims of environmental degradation. It advocates for a bottom-up, people-oriented development approach in order to reach sustainable environmental development where women are prominent actors (Agarwal, 1994; Braidotti et al., 1995). International instruments such as Agenda 21 outline the role of women in environmental management (UNCED, 1992). Ever since as providers of food for their families, women interact very closely with the environment (Chiuri and Nzioki, 1992; UNRISD and Agarwal, 1995).

Gender relations determined largely by social, economic and political structures create inequality that leads to increased vulnerability to women. In these situations women have few options regarding the kind of lifestyle they want to lead and fewer opportunities to change unsatisfactory conditions and improve their families' standard of living and personal health (Chelala, 2001). Women also tend to face discrimination within labour markets and with regard to obtaining housing, land, basic services and credit. (Source: Environmental Health and First Nations Women, 2009)

Environmental hazards can particularly lead to severe health

consequences especially to poor and indigenous women due to their already marginalised status (David Suzuki Foundation, 2007). Furthermore, women are especially susceptible to many environment hazards when pregnant, since the reproductive system is particularly sensitive to adverse environmental conditions. (DANIDA, 2000). Therefore women are more at risk than men to many environmental hazards for variety of reasons.

Kumari (2004) also reveals that women are the direct victims of environmental degradation. She adds that in some areas a few decades back women went to fetch water from sources that were few feet away. But now, because of excessive mining and allied activities, they have to walk miles together for a pot of drinking water.

A global survey of attitudes on the environment, sponsored by United Nations Environment showed that women, when compared with men, are more likely to choose a lower standard of living with fewer health risks rather than a higher standard of living with greater health risk. (Chelala, 2001 & Environmental Health and First Nations Women, 2009). Kumari (2004) further in her study, reveals that women are having base and skills for natural resource management, are sensitiveness towards environment and have high ecological consciousness which is not being highly utilized and neglected.

This argument is further supported as Women in the villages of India, traditionally gather the firewood and raise the alarm when the forests are fading away. They aim to conserve the forests, taking branches and dead wood rather cutting down the trees. The forest provides dead limbs to cook meals and pure water and the trees held the soil along the hillsides thus preventing erosion and landslides. (Panchayat Newsletter)

The role of women in environmental management is now widely recognized, especially in developing countries where obtaining food and medicines, gathering water, fuel wood, making clothing and shelter are women's chores.

### **Women's relation with environment and nature**

Each day, all over the world, women make limitless choices that affect the environment. Women play a very significant role in a family and her community bringing decisive changes. In their hands lie exceptionally extensive decisions about the use of community resources – water consumption for the

household, land use for agriculture purpose, wood collect for heating and cooking, plants and animals for food and sale. They perform fundamental duties such as seed selection and storage for farming activities, multiplication and conservation though they

rarely get the credit for nurturing these life support systems.

According to Maria Mies, (mentioned in Shiva, 1988) women's work in producing sustenance in the production of life, views it as a truly productive relationship towards environment and nature, because 'women not only collected and consumed what grew in nature but they made things grow'. This organic process of growth and development in which women and nature both work in partnership with each other has created a very special relationship of women with nature and which according to Mies can be summarised as follows.

a) Their interaction with nature, with their one nature as well as the external environment, was a reciprocal process. They conceived of their one bodies as being productive in the same way as they conceived of external nature being so.

b) Although in appropriate nature, their appropriation does not constitute a relationship of dominance or a property relation. Women are not owners of their own bodies or of the earth, but they co-operate with their bodies and with earth in order 'to let grow and to may grow'.

c) As producers of new life they also become the first substance producers and the inventors of the first productive economy, implying from the beginning social production and the creation of social relations, i.e. of society and history. (Shiva, 1988)

Women in rural areas actively contribute in many agricultural activities including crop production, horticulture, post-harvest operation, agro-social forestry, fishery etc. Out of total 329 million hector geographical area of India, net sown area is 142 million hector. It is estimated that women are responsible for 70 percent of actual farm work and constitute upto 60 percent of farming population. Over the years women cultivators are typically and wrongly characterised as economically inactive and they play only a supportive role as farmers wives in agriculture. (Samanta, 1994 and Chayal and Dhaka, 2010). Women sow, weed, hoe and bind the stalks in the agricultural field. Besides at home, they manage home gardens, growing a wide variety of vegetables, flowers, trees, herbs, roots etc which become small laboratories where women try out diverse wild plants and indigenous species. Women farmers constantly experiment with plants and animals in order to improve their existing lifestyle in tune with the surrounding ecosystem. Women farmers have in fact been

largely responsible for the improvement and adaptation of many plant varieties. (Nanda, 1995)

In a study done by Chayal and Dhaka (2010), they concluded that women's participation in farming was maximum in cutting, picking, cleaning of grains, drying of grains, storage, processing operations and major part of cleaning of field, raising nursery for seedling, weeding, shifting production to threshing floor, winnowing and grading operations.

The Interdependence of women with nature can be evolved from the following observations made by T. Sita Kumari in the PRP Journal of Human Rights, January-March 2004. They are:

1. Women are having base and skills for natural resource management.
2. They are better managers for natural resources.
3. They have sensitiveness towards environment.
4. They have high ecological consciousness.

"Although they are directly dependent on forest resources, most of the forestry projects are designed without the mention of women and without any recognition of the impact the proposed activity will have on them. Besides, the laws in respect of indigenous women too are inadequate and there is a necessity to specifically incorporate laws, which relate to indigenous women and protect their interests. Once women are organized they will work for the cause with full devotion and face any situation to tide over the obstacles created by gender insensitive policies and practices." (Kumari, 2004)

Some of the recommendations made by Kumari are:

- (i) The protection of women decision-makers, planners, advisers and managers related to environmental management should be increased.
- (ii) The potential of science and Technology should be utilized to solve environmental related problems and ease women's work load inside and outside the home.
- (iii) The central government should develop a strategy to eliminate various obstacles-constitutional, legal, administrative, social and economic in nature to women's full participation in sustainable development.
- (iv) The Government, Non- Governmental Organizations, Environmental Conservation agencies and the common man should recognize and mobilize women as active participants to protect and enrich the natural resources that sustain us.



(v) In spite of all these aspects there must be promotion of disseminating the gender relevant knowledge and valuations of women's role through formal and non-formal education. To look into the matter in a more practical way, Ms. Digambari Devi Rana from Uttar Pradesh had organized a MahilaMandal (Women's Association) for protection of forests around her village. Ms. Rana gave actual day-to-day experience in collection of firewood for home consumption, by women of her village and pointed out that increasing efforts were necessary to collect the requisite firewood, as the existing forestry resources were rapidly getting decreased due to heavy demands from both human populations as well as by grazing cattle.

(<http://www.womenenvironment.in/detail.php?pagelid=218>)

According to the Tamil Nadu Agritech Portal, 2008, some guidelines are suggested for

### **Women world leaders for environment conservation**

Indian village women residing in the hills played an active role in giving birth to early environment movements. It was in the Garhwal region of Uttaranchal (Chamoli district), now known as Uttarakhand during the end of 1972 that the great Chipko Movement got its name and fame. Women of that province played a key role in igniting the fire to save their forest.

The iconic Chipko movement activists included village women, men and Gandhian activists. The movement was to stand against the commercial motives of the state government's to cut and sell trees. Women then came out of their houses led by Gauri Devi, who agitated, hugging trees and engaged in a confrontation with the contractors. The Chipko movement adopted the slogan 'ecology is permanent economy'.

The Chipko Movement brought forth the fact that the primary assets of the forests are soil, water and oxygen and not the timber as conventionally understood. Chipko movement is at the core a women's movement, for her families' survival. Thus, Eco-feminists around the world express Chipko movement as reactionary movement, which ended exploitation.

The obvious name behind Eco-feminism is Sherry Ortner. She coined the term 'Eco-feminism' in order to establish connection between women and nature. Ortner makes this connection to explain the universal subordination of women: 'Since it is always culture's project to subsume and transcend nature,' and women are considered closer to Women in the past as well as present have

ensuring meaningful participation of women in Joint Forest Management committees by considering the immense potential and genuine need for women's participation in JFM programmes. These are:

(i) At least 50% members of the JFM general body should be women. For the general body meeting, the presence of at least 50% women members should be a pre-requisite for holding the general body meeting. At least 33% of the membership in the JFM Executive Committee/ Management Committee should be filled from amongst the women members. The quorum for holding meeting of such Executive/ Management Committee should be one-third of women executive members or a minimum of one whichever is more. One of the posts of office bearer i.e. President/ Vice-President/ Secretary should be filled by a women member of the Committee.

held key policymaking positions in some of the top worldwide environmental protection organizations. These organizations are Greenpeace, World Wildlife Fund, The Sierra Club, The National Audubon Society, The Wilderness Society, The League of Conservation Voters etc.

Katherine Fuller was the President and Chief Executive Officer of the World Wildlife Fund U.S., one of the world's largest nature conservation organizations. She was in that position from 1989 till July 2005. After she became president of The World Wildlife Fund, the organization doubled its revenue as well as membership and developed an environmental educational program called "Windows on the Wild" which is being introduced into middle school curricula around Asia and Latin America. Today she serves on several non-profit boards, lending her innovative and developmental thinking to a wide range of causes. (Miller, 1997)

Vandana Shiva an Indian environmentalist and physicist have worked her whole life in protection and conservation of nature. She founded Research Foundation for Science, technology and Ecology (RFSTE), an institute concerned with biodiversity conservation. She also founded Navdanya to protect the diversity of native seeds. She has spoken out against green revolution as it has brought poverty and environmental destruction (Wheat, 1995). She has also internationally campaigned against genetically engineered foods. She has received 15 national and international awards for her contribution to ecology awareness and environmental preservation and conservation



such as Earth day International Award (1993) and International Award of Ecology (1997). Bina Agarwal serves as Professor of Development Economics and Environment at the University of Manchester, UK. She is also President of the International Society for Ecological Economics. Agarwal has been Vice-President of the International Association for Feminist Economics. For her contributions include on subjects such as land, livelihoods and property rights; environment and development; food security; the political economy of gender; poverty and inequality; law; and agriculture and technological change. She has been honoured with many awards such as Ramesh Chandra award for "outstanding contributions to agricultural economics". In her latest book, *Gender and Green Governance* (Oxford University Press 2010), Agarwal explores the impact of women's presence on forest governance and conservation. ([binaagarwal.com](http://binaagarwal.com))

Greenpeace USA, which was falling apart financially in the early 1990s, regained its virtually lost status after Barbara Dudley became executive director of Greenpeace in the United States in 1993. She is a committed activist on issues ranging from civil and women's rights to the environment and the peace movement for 25 years. Additionally,

In India, women have a momentous role to play in the management of natural resources, but development planners have ignored their subsistent needs and perspectives. Most of the forestry projects have failed to mention the role of women in their planning's and also the impact the proposed project's will have on them. The laws in respect of indigenous women too are inadequate. This largely is because women in the past were not participants in local decision-making bodies such as village councils. But now things have changed, as women are becoming participants in panchayats and other local bodies.

Also we need to realize that the traditional use of forests is threatened by resource depletion, changing family structures, and the introduction of technologies along with developmental projects. It is now again the time for women to rise and start their revolution towards the conservation of environment, ranging from grass root to top brass level.

The Government, Non- Governmental Organizations, Environmental Conservation agencies should mobilize women as active participants to protect and enrich the natural resources and develop a strategy to eliminate

Greenpeace under Dudley has earned crucial environmental victories such as by educating small-time fishermen about sustainable fishing and working to change the focus of its fisheries campaign from 'jobs versus the environment' to 'jobs and the environment'.

Greenpeace International Board of Directors has a number of women leaders, which includes the board chair, Lalita Ramdass. She is an earnest believer of non-violence. Besides Greenpeace, she also works in several other NGOs. Similarly, Ayesha Mei-Tje Imam and Irmi Mussack are the members of Greenpeace International Board of Directors. Ms. Ayesha is also currently working on the Board of WEDO (Woman's Environment and Development Organization). Also Greenpeace organises various programmes to get active participation of women.

In recent times, very few women in India have been actively involved in environment conservation. One of them being Medha Patkar who led the movement called 'Narmada Bachao Andolan', is against the construction of dam in the river Narmada. This movement is also supported by booker prize-winner Arundhati Roy and Bollywood celebrity Amir Khan.

## Conclusion

various obstacles like constitutional, legal, administrative, social and economic in nature to women's full participation in sustainable development. The protection of women decision-makers, planners, advisers and managers related to environmental management ought to be increased.

It is also important to educate women especially in rural areas as education empowers them towards having proper family planning leading to a small family and controlled population. Benefit being direct reduced pressure on the environment for food and fauna resulting in decrease in overall environmental stress and degradation. Also an educated woman gives proper education and direction to her children, which in many ways adds to sustainable development of environment. Thus, an empowered woman can do immense for maintaining the ecological balance.

For the women in urban areas who have less space in their houses and who live in small apartments with small balconies can develop hobbies of in-house and outside gardening. Plants help in interior decoration, beautification as well as in maintaining cleanliness of houses and the surrounding environment. Seeing

greenery provides comfort to the eyes and helps in maintaining health. Some neighbours share saplings and branches of plants to maintain variety in their garden. Besides earthen pots, empty paint buckets and cans, old tins, broken mugs etc. can be used for growing plants. Also plants are available which

do not require much care and attention such as cactus plants like aloe vera, marigold, money plant etc. Thus we need to take care of our natural environments when it is in need as it will help us back when we will be in need. It is a give and take process for better survival in this planet earth.

## References

- Agarwal B.[1992] *The gender and environment debate: Lessons from India*, feminist studies, Vol. 18, no.1
- Agarwala B [1994] *A Field of One's Own: Gender and Land Rights in South Asia*, Cambridge: Cambridge University Press
- Armin Rosencranz, Shyam V, Martha L. N [ (1995) *Environmental Law and Policy in India*, Tripathi Publications, New Delhi
- Braidotti R [1995] *Women, the Environment and Sustainable Development: Towards a Theoretical Synthesis*, London, New Jersey: Zed Books
- Chayal K & Dhaka BL [2010] *Analysis of Role performance of Women in farm activities*, Indian Research Journal of extension education, vol. 10, no.2.
- Chelala C[2001] *Women Taking Charge to Save the Environment*, CommonDreams.org, Retrieved from: <http://www.commondreams.org/views01/0512-12.htm>
- Churi W & Nzioki A [1992] *Women: Invisible Managers of Natural Resources*, in ShanyisaAnotakhasiyani (ed), Groundwork: *African Women as Environmental Managers*, Nairobi: ACTS Press
- David Suzuki Foundation [2007] *A Prescription for a healthy Canada: Towards National Environmental Health Strategy*, Retrieved from: <http://www.davidsuzuki.org/files/SWAG/Health/DSF-Prescription-Healthy-Canada.pdf>
- DNIDA [2000] *Identification the Vulnerable Groups: Who Suffers?*, DNIDA Workshop Papers, Improving the Urban Environments and Reducing Poverty, Copenhagen, Denmark. Retrived from: <http://web.mit.edu/urbanupgrading/urbanenvironment/issues/vulnerable-groups.html>
- Rishi P[1997] *Women and the Environmnet from Empowerment to Sustainable Development*, Kurukshetra, Vol XIV, January- February.
- Rani R [1997] *Environmental Degradation and Women*, Kurukshetra, Vol XIV, January- February.
- Jackson C [1993] *Women/Nature or Gender/History: A Critique of Ecofeminist Development*, Journal of Peasant Studies. 20 (3)
- Kumari S [2004] *The PRP Journal of Human Rights* January- March. Retrieved from, <http://www.womenenvironment.org/detail.php?pagelId=104>,
- Mbote, Kameri P[2006] *Women, Land rights and the Environment: the Kenyan experience*, Development, Society for International Development (SID), Washington, 49 (3)
- Miller S [1997] *Women's Work, The leadership of the environmental movement-and the grassroots rank-and-file-are no longer male preserves*, New York
- Mishra S [1993] retrieved from: <http://www.womenenvironment.org/detail.php?pageId=236>
- Nanda N [1995] *Women and Environment*, Envis CentreState Council for Science, Technology and Environment. Organisation for Economic Co-operation and Development [2001] *Poverty, Environment and Gender Linkeges*, Pre-print of the Dac Journal, Vol 2, No. 4.
- Ortner & Sherry B [1974] *Is Female to Male as Nature Is to Culture*, In *Woman, Culture, and Society*. Ed. M.Z. Rosaldo and L. Lamphere, In *Woman, Culture, and Society*, Stanford: Stanford University Press.
- Owens T & John H [1999] *Investing in Development or Investing in Relief: Quantifying the Poverty Tradeoffs Using Zimbabwe Household Panel Data*, Washington DC: IFPRI.
- Panchayat Newsletter, Retrieved from: <http://www.womenenvironment.org/detail.php?pagelId=237>
- Rana D[1980] *Role of Women in Community Forestry* retrieved from <http://www.womenenvironment.org/detail.php?pagelId=218>
- Sally S[2000], CIDA-Shastri Partnership Project, , retrieved from, <http://www.womenenvironment.org/detail.php?pagelId=243>
- Samanta RK [1994] *The reap less than show*, The Hindu, April issue, Chennai, India
- Sharma R & Kaushik B [2011], *Role of women in environmental conservation*, International Journal of Multidisciplinary management studies, Vol.1, Issue 2. Retrieved from: <http://zenithresearch.org.in> on 17/04/2014.
- Shiva V [1988] *Staying Alive, Women, Ecology and Survival in India*, Kali for women, New Delhi
- Sinha S, Shubhra G & Greenberg B [1997] *The New Traditionalist Discourse of Indian Environmentalism*. Journal of Peasant Studies. 24 (3)
- Sontheimer S [2000] CIDA-Shastri Partnership Project, in Retrieved from: <http://www.womenenvironment.org/detail.php?pagelId=243>
- Turner ,Kathryn G [2003] *Chipko and the Rose-Colored Glasses of Ecofeminism*, Retrieved from: [www.utexas.edu/research/student/urj/journals/Chipko\\_for\\_URJ.doc](http://www.utexas.edu/research/student/urj/journals/Chipko_for_URJ.doc)

- Wheat S [1995] Interview with Vandana Shiva, Environmental Activist – India, New Internationalist Magazine, accessed through Third World Traveler, 21 January 2004. Retrieved from [http://thirdworldtraveler.com/Heroes/Vandana\\_Shiva.html](http://thirdworldtraveler.com/Heroes/Vandana_Shiva.html)
- WWF, retrieved from: <http://www.worldwildlife.org/science/fellowships/fuller/item/5763.html> and <http://www.worldwildlife.org/what/communityaction/people/phe/women/>
- Yadav, N. Women and Environmental Sustainability, retrieved from [http://www.respaper.com/addo\\_punk/2034-pdf.html](http://www.respaper.com/addo_punk/2034-pdf.html)

Websites:

- <http://anthropology-bd.blogspot.com/2008/06/feminist-anthropology.html>
- [http://anthropology.ua.edu/cultures/cultures.php?culture=Feminist Anthropology](http://anthropology.ua.edu/cultures/cultures.php?culture=Feminist+Anthropology)
- [http://en.wikipedia.org/wiki/Women\\_and\\_the\\_environment](http://en.wikipedia.org/wiki/Women_and_the_environment)
- [http://en.wikipedia.org/wiki/Women\\_and\\_the\\_environment\\_through\\_history](http://en.wikipedia.org/wiki/Women_and_the_environment_through_history)
- <http://envirocivil.com/environment/womens-vital-connection-with-environment/>
- [http://foranewleftliberty.blogspot.com/2014\\_05\\_01\\_archive.html](http://foranewleftliberty.blogspot.com/2014_05_01_archive.html)
- <http://foranewleftliberty.blogspot.com/2014/05/feminists-i-want-to-read.html>
- <http://quizlet.com/6905631/introduction-to-geography-people-places-and-environment-flash-cards/>
- <http://womenenvironment.in/detail.php?pageId=104>
- [http://www.afn.ca/uploads/files/rp-enviro\\_health\\_and\\_womwomenen.pdf](http://www.afn.ca/uploads/files/rp-enviro_health_and_womwomenen.pdf)
- <http://www.binaagarwal.com/cv.htm>
- <http://www.bio.davidson.edu/people/kabernd/seminar/2004/gmbios/lh.html>
- <http://www.dennisshulman.com/pub3.htm>
- <http://www.docstoc.com/docs/164679698/The-Ecofeminist-Portrayal-of-Chipko>
- <http://www.docstoc.com/myoffice/recommendations?docId=33094291&download=1>
- <http://www.encyclopedia.com/doc/1O7-universalveil.html>
- [http://www.gendercc.net/fileadmin/inhalte/Dokumente/UNFCCC\\_conferences/Road\\_to\\_Warsaw/gfc-biofiles.pdf](http://www.gendercc.net/fileadmin/inhalte/Dokumente/UNFCCC_conferences/Road_to_Warsaw/gfc-biofiles.pdf)
- <http://www.greenbeltmovement.org>
- <http://www.ibc.gov.et/biodiversity-and-gender/women-and-biodiversity>
- <http://www.ielrc.org/content/e0014.pdf>
- <http://www.iiav.nl/eazines/DivTs/Palestine/2006/No95/thisweekinpalestine/details.php-id=1632&ed=112.htm>
- <http://www.ijssh.org/papers/131-W00008.pdf>
- <http://www.ipedr.com/vol44/007-ICSHH2012-W00008.pdf>
- <http://www.jstor.org/stable/41035361>
- <http://www.palgrave-journals.com/development/journal/v49/n3/full/1100274a.html>
- [http://www.pwc.com/en\\_GX/gx/women-at-pwc/assets/empoweringwomen.pdf](http://www.pwc.com/en_GX/gx/women-at-pwc/assets/empoweringwomen.pdf)
- <http://www.questia.com/read/1G1-229530778/visible-under-the-veil-dissimulation-performance>
- <http://www.thefreelibrary.com/Women's+work.-a019192506>
- <http://www.unep.org/PDF/Women/ChapterThree.pdf>
- <http://www.upstartbayarea.org/accelerator/current-cohort/bay-area-cohort>
- <http://www.ve.org.za/index.php/VE/article/view/487/561>
- <http://www.ve.org.za/index.php/VE/article/view/487/562>
- <http://www.womenenvironment.in/detail.php?pageId=218>