ISSN: 2349-3763

IJENAS

International Journal of Environment and Natural Sciences

Website: www.ijenas.com; Email: journalijenas@gmail.com; © Centre for research in ecology, environment and social sciences (CREESS)

Length-Weight Relationship (LWR) of *Glossogobius giuris* (Hamilton-Buchanan, 1822) of Pumlen Lake-Thoubal, Manipur, India

Ngasepam Romen Singh[1], Biplab Kumar Das [2]* and Devashish Kar[3]

[1,2] Department of Life Science and Bioinformatics, Assam University, Silchar- 788011, Assam, India.
[3]Department of Life Science and Bioinformatics and School of Life Sciences, Assam University, Silchar-788011, Assam, India

*Corresponding author: biplabkumar1987@gmail.com

(Received: November 19, 2014; Accepted: February 4, 2015)

Abstract

The Length-Weight (LW) Relationship is immensely valuable to ascertain well-being of a fish. The fish species *Glossogobius giuris* is under the order Perciformes and the family of Gobiidae. This particular fish species is under the category of least concern according to IUCN 2012. Fishes are an almost zero-carbohydrate food, good for diabetic and other such patients. The value of the Log C is 0.2109 and the value of n is 0.4110. Calculating the LWR for the fish it was found that, growth of fish population is allometric in nature.

Keywords: *Length-Weight Relationship, Glossogobius giuris, Pumlen Lake, India*

Introduction

Fishes are the useful barometer of real state of purity of water. It is the highest tropic level of aquatic ecosystem and is the major material which can be extracted from water mass. The body of fish continually changes with ageing. The weight of fish is a function of its length (Hile, 1936). The condition factor (Kn) in fishes is significant in understanding their nutritional and biological cycles (Simon *et al.* 2007). The knowledge on the length weight of fish has a vital importance in fishery science, as it not only helps to establish the mathematical relationship between the two variables the length and weight, but also to convert one variable into another. It has a wide application in delineating the growth patterns during their developmental pathways and it is also employed in setting up yield equations. Studies on length-weight relationship of fishes are conducted primarily to facilitate the conversion of one measurement into another basically to have an assessment of growth rate of the fish crop (Das *et al.* 2013, 2014). In certain cases the relationship is very useful in differentiating small taxonomic units, as variation may occur with the population of different localities (Le Cren, 1951; Chonder, 1972).

Study Site

The present LWR of the fresh water fish *Glossogobius giuris* of Pumlen Lake, Manipur. Pumlen Lake locally known as Pumlen pat (Pat–A lake in Manipur) is the second largest freshwater wetland located in the southern part of the Manipur valley. The lake is situated in Thoubal District at an appropriate distance of about 50 km from Imphal (Manipur) city towards the southern lowlands of the valley, on the left side of the River Imphal at the geographical coordinates between 93°50'E to 94°0'E and 24°20'N to 24°35'N and at elevation of 767 m MSL.

Materials and Methods

Fish samples were collected from Pumlen Lake using different fishing gears (cast net, hand net and scoop net). The collected fish samples were identified with the standard literature of Jayaram (1999), Kar (2007, 2013). A total length of each fish was measured to the nearest 0.01cm and individual body weight was recorded to the nearest 0.01g.

In fishes, generally the growth pattern follows the cube law. Such relationship for the fishes will be valid when the fish grows isometrically. In such cases, the experimental value must be exactly 3. But, in reality, the actual relationship between length and weight may depart from the ideal value due to environmental conditions or condition of fish (Shadi *et al.* 2011). This relationship is expressed by the equation $W = aL^n$ …………… (1). This equation was used by several workers for different fish species form different habitats.

Fish samples were collected through netting operations during June 2012 to July 2013. Individual measurements of *Glossogobius giuris* pertaining to total length (TL cm) and total weight (gm) were done with the help of precision Vernier Calliper and Digital Sartorious Electronic Balance respectively. The total length (TL) of each fish species were taken from tip of snout to longest ray of caudal fin.

The LWR was established by fitting equation of the form
$\mathbf{W=cL^n}$…………………… (2)

Where W is the weight of the fish, 'L' its length and 'c' and 'n' are constants. The equation 1 could be expressed in the linear form by using logarithms, as given below:

Log W = Log c + n Log L

$$Log\ C = \frac{\sum Log\ W \times (\sum LogL^2) - \sum Log\ L \times \sum(LogL \times LogW)}{N(\sum LogL^2) - (\sum (LogL)^2)} \quad \text{……………………………………… (3)}$$

The estimates of the constants c and n were obtained empirically by using the formulae, as given below:

$$n = \frac{\sum Log\ W - NLogC}{\sum og\ L} \quad \text{……………………………………… (4)}$$

Significance of the variation in estimates of n from the expected value 3 (cube law). Weights were estimated for different lengths using relationship equation. The relation between length and weight for each fish was computed with help of statistics. The Fulton's Condition Factor (K) was computed by using the formulae, as given below:

$$Condition\ Factor\ (K) = \frac{Weight\ (g)}{(Length)^3\ (cm)} \times 100 \quad \text{……………………………………… (5)}$$

Results

The total of 50 specimens of *Glosogobius giuris* belonging to under order Perciformes family Gobiidae from Pumlen Lake were used in the analysis. The number of specimens, LWR, Fultons Condition Factor and Le CrenCondition Factor are presented in table (Table 1)**.** The value of the Log C is 0.2109. It is evident from the result that the 'n' value of length-weight relationship was found 0.4110; represents fish that becomes less routed as length increases, indicating the allometric pattern of growth in the fish.

The computed correlation co-efficient (r) value in *Glossogobius giuris* was found to be 1 which indicates, there is high positive correlation between the length and weight in the species. The results obtained from this study are useful to fisheries scientist. In summary, this study updates length-weight parameters for many species encountered by bottom trawl. The differences in weight for all the sampled batches may be due to the individual condition factor as it relates to the well-being and degree of fatness (Pauly, 1983). The Condition factor (K_n) is an indication of general well being of fishes.

While plotting, the observed average weight of the species against the observed length with a predicted data, a parabolic curve has been obtained.a logarithmic graph prepared with the observed data of log L and log W with a predicted data showed a straight line relationship.

Discussion

There is relationship between length and weight in the fish of *Glossogobius giuris*; but the fish follow the cube law strictly and the weight increase was a rate of the cube of its length in all the samples collected from spatially and geographically different places characterized by different environmental conditions (Prasad and Ali, 2007). The condition factor (K) reflects, through its variations, information on the physiological state of the fish in relation to its welfare. The current interpretation of the parameters resulting from the LWR of the species could disclose information which may be is useful to the study of fishery biology and management of fishes.

References

Chatterji A [1980] The relative condition factor and length-weight relationships of a freshwater carp.*Labeogonius* (Hamilton).*J. Bombay Nat. Hist. Soc.* 77 (3): 435-443.

Chonder SL[1972] Length-weight relationship of mature female *Labeogonius* (Hamilton) from the Keethan reservoir.*Journal of Inland Society India*. 4: 216-217.

Das BK, Kar D [2011]. Habitat Mapping, Spatial Analysis to Fish Diversity of River Subansiri during Winter Season in Assam and Arunachal Pradesh (India). *Environment and Ecology.*29 (4A): 1948-1951.

Das BK, Dutta B, Singh NgR & Kar D [2013] Length-Weight Relationship of *Labeocalbasu* (Hamilton-Buchanan) from SoneBeel the Biggest Wetland of Assam, India.*PARIPEX- Int. Journal of Research.* 2 (10): 11-13.

Das BK, Chakraborty A & Kar D [2013] Calculation of Length of a Fish Using Two-Dimensional Geometry.*International Journal of Scientific Research.* 2 (10): 48-51.

Das BK, Dutta B, Kar S, Boruah P & Kar D [2013] Icthyofauna of Subansiri River in Assam and Arunachal Pradesh, India.*International Journal of Current Research.*5 (11): 3314-3317.

Das BK, Boruah P & Kar D [2014] Study of Seasonal Variation of Water Quality of River Siang in Arunachal Pradesh, India.*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT).* 8 (2IV): 11-20.

Das BK, Singh NgR, Dutta B. & Kar D [2014] Length Weight Relationship of *Labeorohita*(Hamilton-Buchanan) and *Labeogonius* (Hamilton-Buchanan) in SoneBeel, the biggest Wetland of Assam, India. *Journal of environmental Research and Development.* 8 (3A): 587-593.

Das S, Das T, Das BK. & Kar D [2014] Length-Weight Relationship and Condition Factor in *Barilius sacra* of River Torsa in West Bengal.*International Journal of Scientific Research and Reviews.*3 (3): 65 – 69.

Hile R [1936] Age and growth of Cisco, *Leucicthysartedt*(Le Seum) in the north-eastern high lands.Wisconsin Bull.U.S. Bur. Fish. 48: 211-317.

Jayaram KC[1999] The freshwater fishes of the Indian region, Narendra Publishing House, Delhi, India.pp. xvii+ 551 pp.

Kar D [2007] Fundamentals of Limnology and Aquaculture Biotechnology.Daya Publishing House. New Delhi. India. pp. xiv + 609 pp.

Kar D[2013] Wetlands and Lakes of the World, Springer (London).pp. xxx + 687.

L Cren [1951] The Length-Weight relationship and Seasonal cycle in Gonad Weight and condition in Perch, *Journal of Animal Ecology.*20: 201-209.

Oribhabor BJ, Ogbeibu AE & Udo MT[2011] The Length-Weight Relationships of Brackish Water/Marine Fish Species Assemblage in a Niger Delta Mangrove Creek, Nigeria, *Current Research Journal of Biological Sciences.* 3 (6): 616-621.

Pauly D[1984] Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators. ICLARM. Manila, Philippines, 325 pp.

Prasad G , Ali APH [2007] Length-Weight Relationship of a Cyprinid fish *Puntiusfilamentosus*from Chalkundy River, Kerala. 22 (3): 2637-2638.

Simon KD, Mazlan AG [2008] Length-Weight and Length-Length Relationships of Archer and Puffer Fish Species, *The Open Fish Science Journal.* (1):19-22.

Shadi A, Mediseh SD, Kouchanian P & Gandomi Y [2011] Length-Weight Relationships for 6 Fish Species from Khuzestan (North of Persian Gulf), Iran, *World Journal of Fish and Marine Sciences.*3 (2): 129-131.

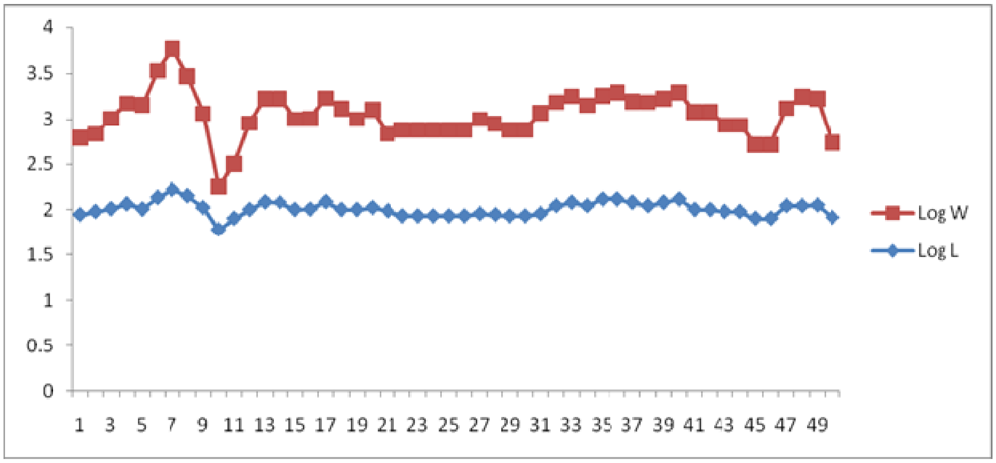

Figure 1. The relationship between Total length (cm) and Body weight (gm) of *Glossogobius giuris*

Table 1. Length-Weight Relationship of *Glossogobius giuris*

Sl. No	Length (mm)	Weight (gm)	Log L	Log W	Log L^2	Log L × Log W	Fultons Condition Factor (K)	La Crens Condition Factorm(Kn)
1	88	7	1.944483	0.845098	3.78101286	1.643278495	1.027188204	6.93012783
2	95	7.1	1.977724	0.851258	3.91139066	1.68355373	0.828109054	6.93532486
3	102	10	2.0086	1	4.03447465	2.008600172	0.942322335	9.648461484
4	115	13.1	2.060698	1.117271	4.24647559	2.302358546	0.861346264	12.38364558
5	101	14.2	2.004321	1.152288	4.01730417	2.309556157	1.37823801	13.72410188
6	135	25.1	2.130334	1.399674	4.53832197	2.981772194	1.02016969	23.1024006
7	165	36	2.217484	1.556303	4.91723504	3.451075808	0.801402454	32.07738774
8	141	21	2.149219	1.322219	4.61914279	2.841738979	0.749138223	19.19159421
9	105	11	2.021189	1.041393	4.08520618	2.104851751	0.950221358	10.56058664
10	60	3	1.778151	0.477121	3.16182187	0.848393756	1.388888889	3.185659727
11	80	4	1.90309	0.60206	3.6217515	1.145774341	0.78125	4.027913502
12	100	9	2	0.954243	4	1.908485019	0.9	8.713331397
13	121	14	2.082785	1.146128	4.3379949	2.387138705	0.790263502	13.12182468
14	120	14	2.079181	1.146128	4.32299465	2.383007917	0.810185185	13.14006806
15	100	10	2	1	4	2	1	9.68147933
16	101	10	2.004321	1	4.01730417	2.004321374	0.970590148	9.66486048
17	122	14	2.08636	1.146128	4.35289734	2.391235494	0.770989642	13.10378141
18	100	13	2	1.113943	4	2.227886705	1.3	12.58592313
19	100	10	2	1	4	2	1	9.68147933

20	105	12	2.021189	1.079181	4.08520618	2.181229586	1.036605118	11.52063997
21	97	7	1.986772	0.845098	3.94726192	1.679016899	0.766977877	6.812896187
22	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
23	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
24	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
25	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
26	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
27	90	11	1.954243	1.041393	3.81906379	2.035133854	1.508916324	10.8471242
28	88	10	1.944483	1	3.78101286	1.944482672	1.467411721	9.900182614
29	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
30	85	9	1.929419	0.954243	3.72265739	1.841133557	1.465499695	8.965115137
31	90	13	1.954243	1.113943	3.81906379	2.176915452	1.783264746	12.8193286
32	110	14	2.041393	1.146128	4.1672841	2.339697388	1.051840721	13.33444589
33	120	15	2.079181	1.176091	4.32299465	2.445306889	0.868055556	14.07864435
34	110	13	2.041393	1.113943	4.1672841	2.273995811	0.976709241	12.38198547
35	130	14	2.113943	1.146128	4.4687565	2.422849742	0.63723259	12.96619589
36	130	15	2.113943	1.176091	4.4687565	2.486190299	0.682749203	13.89235274
37	120	13	2.079181	1.113943	4.32299465	2.316090127	0.752314815	12.20149177
38	110	14	2.041393	1.146128	4.1672841	2.339697388	1.051840721	13.33444589
39	120	14	2.079181	1.146128	4.32299465	2.383007917	0.810185185	13.14006806
40	130	15	2.113943	1.176091	4.4687565	2.486190299	0.682749203	13.89235274
41	100	12	2	1.079181	4	2.158362492	1.2	11.6177752
42	100	12	2	1.079181	4	2.158362492	1.2	11.6177752
43	95	9	1.977724	0.954243	3.91139066	1.887227936	1.049715702	8.791256865
44	95	9	1.977724	0.954243	3.91139066	1.887227936	1.049715702	8.791256865
45	80	6.5	1.90309	0.812913	3.6217515	1.547047269	1.26953125	6.545359441
46	80	6.5	1.90309	0.812913	3.6217515	1.547047269	1.26953125	6.545359441
47	110	12	2.041393	1.079181	4.1672841	2.203032702	0.901577761	11.42952505
48	110	16	2.041393	1.20412	4.1672841	2.458081725	1.202103681	15.23936673
49	112	15	2.049218	1.176091	4.1992945	2.410067404	1.067670372	14.24327465
50	82	6.6	1.913814	0.819544	3.66268346	1.568454536	1.197022678	6.616690646

ISSN: 2349-3763

IJENAS

International Journal of Environment and Natural Sciences

Website: www.ijenas.com; Email: journalijenas@gmail.com;

Assessment of the impacts of vehicular emissions on urban air quality near highly traffic intersections area of Dhanbad Region, Jharkhand, India

Ashok Kumar Dubey[1]*, Gurdeep Singh[1], Refinald Ebhin Masto[2], Joshy George[2], Bijendre Kumar[1] & Sridevi Jena[1]

[1]Department of Environmental Science and Engineering, Indian School of Mines, Dhanbad, Jharkhand., India
[2]Environmental Management Division, Central Institute of Mining and fuel Research, Digwadih, Dhanbad, Jharkhand, India

Corresponding author's E-mail: ashokkdubey90@gmail.com

(Received: November 15, 2014; Accepted: February 4, 2015)

Abstract

Dhanbad, the city of Jharkhand is famous for its coal reserve. The air quality of this city always has been center point among researchers. Vehicular emissions have been major source for air quality crises in Dhanbad after mining. This study assessed the effect of vehicular emissions on air quality of high traffic intersection. In order to find pollution behavior at different shift of the day air quality survey was conducted at four prominent locations. In the result, it is seen that all the key pollutant concentration are above the permitted level. It is highest in third shifts (16:00-20:00) when traffic is maximum. Principal component identifies possible correlation between source and pollutant,this establishes that increase in vehicular traffic dramatically increases pollutant concentration namely Pb, PM_{10}, $PM_{2.5}$, CO at major intersection of the city.

Keywords: *Vehicular emission, PM_{10}, $PM_{2.5}$, Principal component analysis (PCA)*

Introduction

World's population is increasing rapidly; people are migrating in large number from rural to urban areas in order to achieve better life and better facilities. This is directly associated and uplifting human standard this further increases use of electronic machine, appliances, transport vehicles etc. India is a developing country aspiring to be developed; its urban population growth rate is higher than the national average (Ghose, 2002). Thus, middle class population of India requires better transportation facilities to reach their destination, in order to do this demand of vehicles on road has increased rapidly in last few decades but this made a problem to the environment by continuously polluting ambient air of urban areas. Even after implementation of certain laws and technological upgradation things are insufficient to counteract with vehicular air pollution. This has been always been the reason to increased concentration of gaseous and particulate pollutant in the urban atmosphere. This significant concentration of pollutants directly affect human health and cause several known and unknown ailment. Prominent pollutant emitted from Motor vehicle is carbon monoxide, SOx, NOx and particulate matter (Davis, 1998). According to the study conducted by (Anon, 1995) vehicular emission are the major source of PM_{10} in urban atmosphere. NO_2 emitted from vehicles produce secondary pollutant named O_3 after photochemical reaction (Steinberg et al., 1991).In order to assess air quality at different road intersection of Dhanbad city, extensive survey was conducted. The most important reason to conduct this study was to indicate the traffic pollution related problem of this industrialized city which is famous for coal mining activities. There has been extensive research data available regarding pollution through mining activities but traffic related pollution has not been reported for this area. City roads plying with more than 6,000 auto rickshaws and number of car , buses, truck, dumper and two wheeler which have been affecting air quality, this might be disturbing or causing health problems. So the focus area of this paper is to do comparative assessment of nine parameter namely Pb, As, Ni, B(a)P, CO, PM_{10}, $PM_{2.5}$, SO_2, NO_2 out of twelve by given CPCB guidelines 2009.Principle component analysis was carried out to acesses correlation between selected pollutants at four specific road intersections from where more than 75% city traffic passes daily. This result would be helpful for implementation of certain rules in order to abate and develop of technologies to remediate problems.

Study Area

Dhanbad is the third largest city of Jharkhand state of India. It is located between 23 37' 3" N and 24 4' N latitude and between 86 6' 30" E and 86 50'E longitude its length spreading 44 miles North and 48 miles South. This region comes under Chota-Nagpur plateau and is known as coal capital of India because of huge coal reserve. Several reports have been published about the air quality of Dhanbad city and its surrounding areas. But the main purpose of this work is to shift the point of concern from mining generated air pollution to vehicular air pollution, uncontrolled vehicular density, bad traffic management, poor road condition, large number auto rickshaws as a public convince. These all factors are collectively responsible for degrading city air quality.

Data collection methods

For air quality monitoring of ambient air, monitoring stations were selected at important traffic intersections (Figure 1). Sampling was conducted during July to September 2014 twice in a week (working day only). Samples were collected in four shift of the day sequentially starting from morning (8:00-12:00h), after noon (12:00-16:00h), evening (16:00-20:00h), night (20:00-8:00) (Table 1) (Banerjee et al., 1996). While meteorological data was collected from meteorological station installed on roof top of Environment Department, Indian School of Mines (ISM) (Ghose and Majee, 2000). The sample were collected at sampling location on EPM 2000 filter using Repairable Dust Sampler (RDS). PM2.5 sample was collected on PTFE filter using Fine Particulate Sampler (FPS), this is manufactured by Envirotech Ltd., New Delhi. These were equipped with impinger bottles in series with sodium tetrachloromercurate at 0.5 l/min for SO_2 absorption (IS: 5182, Part 2 1969) and sodium hydroxide maintained with 0.5l/min of flow rate for 24 h in order to absorb NO_2 (IS: 5182, Part 5 1976). After sampling, impinger bottles placed in refrigerator prior to analysis (Ghose and Banerjee, 1995). The prepared samples of SO_2 were analyzed through spectrophotometer (by West and Geake) while Jacob and Hocheiser used for NO_2 analysis (APHA, 1977).

PM_{10} and $PM_{2.5}$ were calculated after weighing the glass fibre filter. For Carbon monoxide determination, atmospheric air was sampled in glass tube with flow rate of 0.2l/min for 5 min, in a vacuum (700 cm^3 of Hg) tube.There after, known volume of air was sucked through syringe and drawn into Gas Chromatograph column (CO Prepack-Q with mithanizer and HC only Porapack-Q). For determination of metals namely Pb, As and Ni filter containing particulate sample, were digested in microwave digestion (Ethos E, Milestone, Italy). Then, prepared samples were analyzed by inductively coupled plasma optical mass spectroscopy. (ICP-OES) For Benzo(a)Pyrene quantification, particulate containing filter tear into small pieces and put into the Teflon vessels with 1:1 mixture of acetone and ethanol for microwave digestion.In the end, the prepared sample was analyzed by Gas chromatography and mass spectroscopy (GC-MS).

Results and Discussion

The objective behind the collection of air pollutants was to evaluate the vehicular emissions and their possible impact on city air quality at major traffic intersections. In the study we found average Pb concentration ranged from 0.605 µg/m^3-0.674 µg/m^3, where as the highest mean concentration was found to be SA4 (Bank-More).This average concentration exceeds the permissible limit prescribed by Central pollution control board (CPCB) of 0.50µg/m^3.The average concentration of lies between the range of 0.01225 µg/m^3 (at SA3) to 0.01502 µg/m^3 (at SA4). It is important to observe that the concentration of As was not significantly affected, by shift difference. Therefore, it can be said that concentration was near constant level throughout the four shifts of sampling period. As concentration were found above the permissible limit of CPCB (.006µg/m^3).From the result it may be noted that the Ni concentration found was between 0.033 µg/m^3 (at SA2) - 0.0357 µg/m^3 (at SA4) which is comparable with permissible limit given by CPCB (0.002 µg/m^3).It may be noted that the concentration of B (a) P lies between the range from 0.0024 µg/m^3 (at SA4) to 0.00267 µg/m^3 (at SA2). From this finding it is established that the concentration of B(a)P decreases from location SA1 to SA3.This might be due to coal combustion activity. Concentration of CO ranged between 5086 µg/m^3 (SA1)-5781.5 µg/m^3 (SA3). Incomplete combustion of fossil fuel is major source for CO emissions from vehicles. So the correlation may be directly done with large number of vehicle movement. From the result it is found that Shramik Chouk showed highest concentration due to constant traffic flow during all the shifts and it is located next to railway station. The average concentration of PM10 lies between 213 µg/m^3 (at SA1) to 260 µg/m^3 (at SA4) it is a significant marker for diesel exhaust emission in urban environment. The concentration exceeded permissible limit given by CPCB (100 µg/m^3).Whereas the average concentration found for PM2.5 lies between 85.25 µg/m^{3}at SA1 to 118.5 µg/m^3 for SA4, the concentration showed above the CPCB standard (40µg/m^3). It may be noted from the figure 2 (h) that the concentration of SO_2 found between the ranges of 93.5 µg/m^3 (at SA2) - 111.5 µg/m^3 (at SA4). Fossil fuel contains sulfur in significant amount, burning of diesel or petrol produce SO_2 in urban atmosphere. The concentration exceed above the standard prescribed by CPCB (50µg/m^3). The concentration on NO_2 found between 137.25 µg/m^3 (at SA1) to 156.25 µg/m^3 (SA4). The average concentration showed an increase from sampling location SA1 to SA4. Concentration can be directly? shows the traffic condition of the road intersection. The NO_2 concentration was found above the CPCB limit (40µg/m^3).

Factor analysis

The principal application of factor analysis is used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors. Therefore, factor analysis can be applied as a data reduction method. PCA was performed by the varimax rotated Factor Matrix method, based on the orthogonal rotation criterion that maximizes the variance of the squared metals in the column of a factor matrix. This method focuses on cleaning up the factors. It produces factors that have high correlations with one smaller set of variables and little or no correlation with another set of variables (Stevens, 1996). Correlation matrix were developed as shown in Tables 2 for study areas respectively, clearly indicates that how the data points are correlated with each other. Gaseous Pollutant NO_2 is significantly correlated with four parameters at the level of 0.01 (PM_{10} and SO_2 having r values 0.83 and 0.89 while CO and $PM_{2.5}$ having r values 0.743 and 0.714 respectively).

Arsenic is correlated with Pb and Ni with r values 0.69 and 0.78 because the source of emission of these metals is same; industrial and automobile emission. SO_2 is correlated with CO and PM_{10} as they are emitted from road transport. Emissions grow with the increase in vehicle number plying on roads of the city. Table 3 presents the Principal Component (PC) loadings for the air pollutant of the study area with corresponding Eigen values and variances.

The data for air pollutants were interpreted on the basis of two common factors. Three PCs with Eigen values for?? greater than 1.0 were extracted with 47.90% and 79.98% cumulative variance for study areas respectively. The first factor (PC 1) with 47.90% total variance shows highest loadings for NO_2 and PM_{10}. This revealed close association of NO_2 with the vehicular emission. PM_{10} is mainly contributed from a variety of mobile and stationary sources such as heavy vehicle and light vehicles. The second factor (PC 2) contributed 32.08% as high loadings of Pb, Ni and As. These trace metals are well known to be associated with the industrial and automobile emissions (Ahumada et al., 2007; Cetin et al., 2007; Querol et al., 2007). High loadings of Pb and Ni is due to emissions from vehicular exhaust (Ramadan et al., 2000; Weckwerth, 2001; Ragosta et al., 2002; Kim et al., 2002; Hafner et al., 2004; Shah et al., 2006). Lead in the urban environment is road traffic as suggested by Ayras and Kashulina, 2000. High loading of As is due to air ariseing from the smelting of metals, coal mining, industrial activities, the combustion of fuels, especially of coal in coke oven plant. After investigation of results it can be concluded that in the study area, source contribution is mainly due to vehicular emission while second due to coal mining and industrial activities.

Conclusion

This study of air quality monitoring reveals that air pollution at major traffic intersections in Dhanbad is critical and concentration is at threatening level. In the city, motor vehicle remains the major source of air pollution. All monitoring sites showed pollutant behavior change with shift of the day. PCA recognized that vehicular movement is the main contributor of air pollutants in the study area. This study recognizes the necessity stringent inspection and maintenance programs. There is no systematic study reported for Dhanbad which is major industrialized city of eastern India. The outcome of this work may provide a significant data base to outline appropriate schemes for necessary mitigative/preventive measures.

References

Ahumada, H.T., Whitehead, L., Blanco, S., 2007 Personal exposure to PM2.5 and element composition-a comparison between outdoor and indoor workers from two Mexican cities*Atmospheric Environment*41, 7401–7413

Anon, 1995 Diesel Exhausts a Critical Analysis of Emissions, Exposureand Health Effects. Health Effect Institute, Cambridge, MA.

APHA, 1977 Methods of Air Sampling and Analysis, second ed. APHA, Washington

Ayras, M., Kashulina, G., 2000 Regional patterns of element contents in theorganic horizon of podzols in the central part of the Barents region(Finland, Norway and Russia) with special reference to heavy metals(Co, Cr, Cu, Fe, Ni, Pb, V and Zn) and sulphur as indicators of airbornepollution. *Journal of Geochemical Exploration* 68, 127-144

Cetin, B., Yatkin, S., Bayram, A., Odabasi, M., 2007 Ambient concentrationsand source apportionment of PCBs and trace elements around anindustrial area in Izmir, Turkey*Chemosphere*69, 1267-1277

Davis, G.C., 1998 Transportation Energy Data Book, Edition 18, ORNL-6941 Oak Ridge National Laboratory, Oak Ridge, TN

Ghose, M.K., 2002 Control of motor vehicle emission for a sustainablecity. TERI Inform. Digest Energy Environ. 1 (2), 273–281

Ghose, M.K., Majee, S.R., 2000a. Status of air pollution in Indian opencastcoal mines. Minetech 21 (2), 48–52.

Ghose, M.K., Banerjee, S.K., 1995 Status of air pollution caused by coalwashery project in India. *Environ. Monitor. Assess.* 38, 97–105

Hafner, H.R., Wheeler, N.J., Roberts, P.T., 2004. Analysis of Air ToxicsMonitoring Data Work Plan, prepared for Lake Michigan Air DirectorsConsortium, Des Plaines, IL, by Sonoma Technology, Inc., Petaluma, CA,STI-903555-2442-WP2, and January, 41 pp.

Kim, K.H., Lee, J.H., Jang, M.S., 2002 Metals in airborne particulate matterfrom the first and second industrial complex area of Taejon City, Korea.*Environmental Pollution* 118, 41-51

Ramadan, Z., Song, X.H., Hopke, P.K., 2000 Identification of sources ofphoenix aerosol by positive matrix factorization. *Journal of the Air andWaste Management Association* 50, 1308-1320.

Ragosta, M., Caggiano, R., D'Emilio, M., Macchiato, M., 2002 Source originand parameters influencing levels of heavy metals in TSP, in anindustrial background area of Southern Italy *Atmospheric Environment*36, 3071-3087

Shah, M.H., Shaheen, N., Jaffar, M., Khalique, A., Tariq, S.R., Manzoor, S.,2006. Spatial variations in selected metal contents and particle sizedistribution in an urban and rural atmosphere of Islamabad, Pakistan.*Journal of Environmental Management* 78, 128-137.

Stevens, J., 1996. Applied Multivariate Statistics for the Behavioral Sciences(3rd edition). Mahwah, Erlbaum, NJ

Steinberg, J.J., Janet, L., Gilson, D.G. 1991.The pathobiology ofozone-including damage. Arch. Environ. Health 46, 80–87.

Querol, X., Viana, M., Alastuey, A., Amato, F., Moreno, T., Castillo, S., Pey,J., de la Rosa, J., de la Campa, A.S., Artinano, B., Salvador, P., DosSantos, S.G., Fernandez-Patier, R., Moreno-Grau, S., Negral, L.,Minguillon, M.C., Monfort, E., Gil, J.I., Inza, A., Ortega, L.A., Santamaria, J.M., Zabalza, J., 2007 Source origin of trace elements in PM fromregional background, urban and industrial sites of Spain. *AtmosphericEnvironment*41, 7219-7231

Weckwerth, G., 2001. Verification of traffic emitted aerosol components inthe ambient air of Cologne (Germany). *Atmospheric Environment* 35, 5525-5536

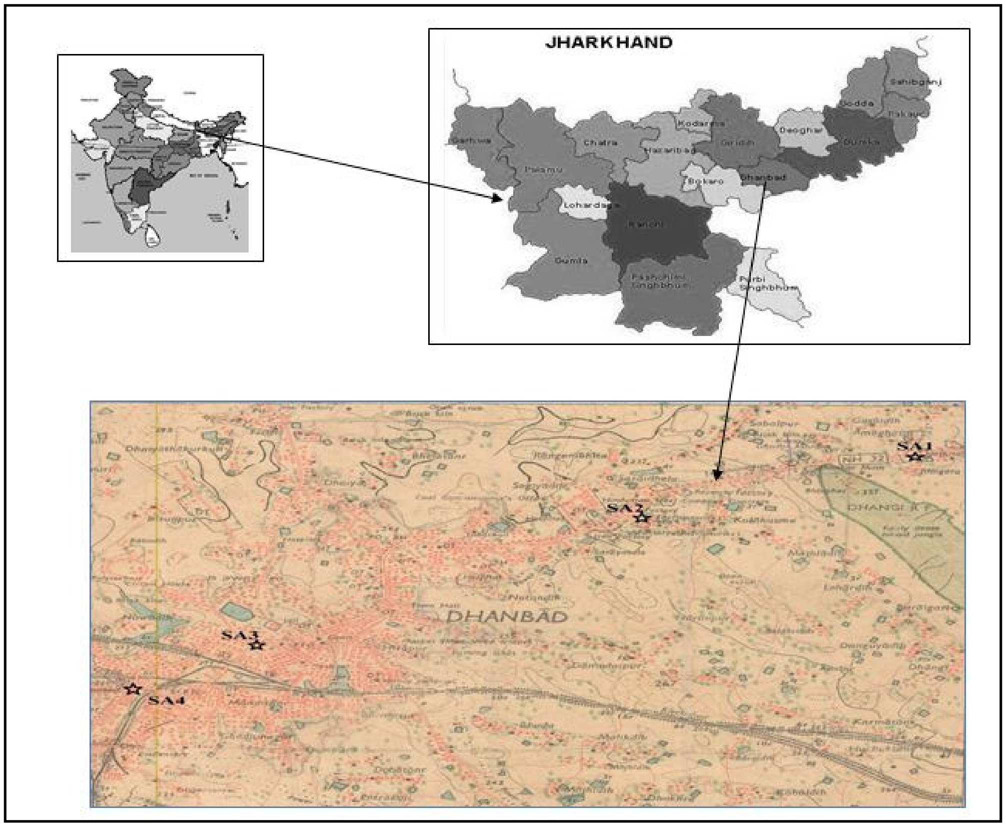

Figure 1. Air quality monitoring stations were selected at traffic intersections in the area

Table 1.Location of monitoring station and relevant features

Sampling Location	Location code	Remarks
Govindpur	SA1	Intersection of NH32 and NH2, Heavy vehicles movement and commercial activities.
Steel Gate	SA2	Two road intersect with NH32, Light vehicle movement, commercial/residential activities
ShramikChowk	SA3	Station road intersect with NH32, Light vehicles movement, commercial activities
Bank-More	SA4	Intersection of SH12 with NH32, Light/Heavy vehicles movement, commercial activities

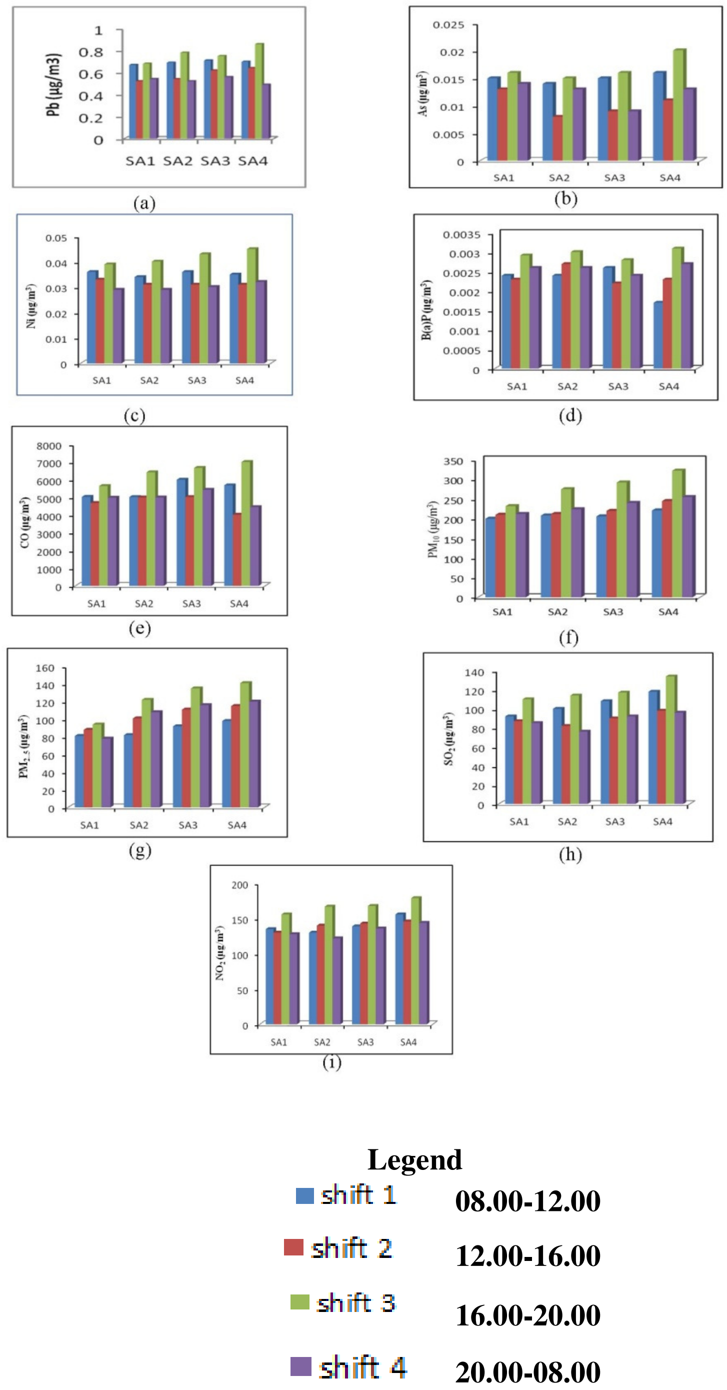

Figure 2. Shift wise concentrations at traffic intersection

Table 2. Correlation matrix different pollutant for the study area

	Pb	Ni	B(a)P	CO	PM_{10}	$PM_{2.5}$	SO_2	NO_2	As
Pb	1	.873	.304	-.265	.110	.097	.105	.141	.697
Ni		1	.517	-.209	.213	.228	.301	.288	.783
B(a)P			1	.129	.578	.706	.373	.399	.342
CO				1	.635	.481	.775	.743	-.437
PM_{10}					1	.905	.691	.834	-.141
$PM_{2.5}$						1	.497	.714	-.020
SO_2							1	.890	-.077
NO_2								1	-.137
As									1

Table 3. Principal component loading of different pollutant for the study area

Factors	Components	
	PC1	PC2
Pb	0.240	0.855
Ni	0.406	0.876
BAP	0.666	0.384
CO	0.687	-.583
PM10	0.926	-.140
PM2.5	0.857	-.033
SO2	0.851	-.150
NO2	0.926	-.162
As	0.022	0.912
Eigen Value	04.311	02.887
%Variance	47.900	32.082
% Cumulative Variance	47.900	79.982

ISSN: 2349-3763

IJENAS
International Journal of Environment and Natural Sciences
Website: www.ijenas.com; Email: journalijenas@gmail.com; © Centre for research in ecology, environment and social sciences (CREESS)

Characteristics of diatom communities epiphytic on *Padinagymnospora* (Kutzing) Sonder, from Central West Coast of India

Vikrant Ashok Kulkarni* & Sandesh Pandurang Jagdale

Department of Biology, Dapoli Urban Bank Senior Science College, Dapoli, Maharashtra, 415 712

**Corresponding author's E-mail:* kulkarnivikrant6@gmail.com

(Received: January 19, 2015; Accepted: February 4, 2015)

Abstract
Epiphytic diatoms among marine microalgae are of special interest for their environmental, biochemical and biotechnological applications. However, seaweeds particularly from the tropics have remained unexplored for their epiphytic flora. Diatom floras associated with *Padinagymnospora* were evaluated for their community structure. Diatom communities were highly diversified and were represented by 53 species, observing dominant genera *Navicula, Rhizosolenia, Nitzschia, Grammatophora* and *Caloneis* from relatively less or non-polluted localities. Composition from polluted areas typically supported one community hypothesis, with dominance of *Biddulphia* and *Licmophora*. Species diversity was found to be inversely related with nutrient concentrations in ambient waters. The present study proved that epiphytic diatoms on seaweeds could serve as reliable ecological indicators.

Keywords: *Epiphytic Diatoms, Seaweeds, Padinagymnospora, Bioindicators.*

Introduction

Seaweeds form a major source of organic matter in near shore waters, and harbor various kinds of associated and epiphytic biota (Chemello and Milazzo 2002; Ranjitham et al. 2008). Epiphytic flora of marine macrophytes prominently constitutes diatoms, cyanobacteria and fungi (Dere et al. 2002; Shamsudin and Sleigh 1995). Diatoms are of a special interest because of their attachment to living substrate and interactions among different components of habitats, contributing to about 40% of the biomass (Falkowski et al. 1986). Most of the earlier work done on epiphytic diatoms dealt with freshwater and estuarine environments (Main and McIntire 1974; Penhale 1977; Sullivan and Currin 2000).
The limited mobility of epiphytic diatoms makes them likely to reflect long term environmental conditions for a particular area (Fore and Grafe 2002). Therefore, they potentially can be use as bioindicators of environmental quality, and may be more effective than other conventional bio-indicators (Fisher and Dunbar 2007; Sudhakar et al. 1994). Understanding dynamics of diatom community structure would enable exploring ecological, environmental as well as biotechnological potentials of such forms.
In view of the above, community structures of diatoms associated with *Padinagymnospora* (Kutzing) Sonder, were evaluated along the central west coast of India. Present efforts could enhance knowledge on seaweed ecology with respect to host epiphytic interrelation and productivity, and contribute towards marine biodiversity.

Materials and methods

Description of study area:

The study locations were selected along the central west coast of India, between latitude 15° - 17° N and longitude 73° 15' - 74° 30' E, a stretch of about 683 km. Based on the rich algal biodiversity and varying water quality, three sampling stations were selected in Mumbai, Malvan and Anjuna (Figure1). Mumbai (18^0 54' N 72^0 48' E), a cosmopolitan mega city, has a number of sources of pollution; both industrial and sewage effluents are freely discharged in the marine waters. Malvan (16^0 03' N 73^0 27' E)represents a relatively better formation of rocky intertidal coast with no obvious sources for pollution, and hence the near shore waters remain relatively clear. Anjuna (15^0 35' N 73^0 44' E) has large rocky cliffs, moderate intertidal expanse, and numerous tidal pools which form the best suitable habitat for algal growth.

Sampling:

Hydrological and biological samples were collected monthly at selected stations during November 2012 – May 2013. pH, temperature, salinity, suspended solids and nutrient concentrations (NO_3^-, NO_2^- and PO_4^-) in ambient waters were estimated using standard oceanographic techniques (Strickland & Parson 1972). Thalli of *P. gymnospora* along with holdfasts were collected from rocky shores and tide pools in mid intertidal zones, gently transferred in polythene bags so as to minimize the loss of epiphytes, and were immediately stored at ~ 0 – 4º C.

Isolation and identification of diatoms:

Epiphytic diatoms on *P. gymnospora*were isolated by adopting and slightly modifying the HCl digestion methods described for aquatic angiosperms (Shamsudin and Sleigh 1995). Thalli collected were weighed and added to 1.5% HCl at 30° C, and rotated on shaker at 120 rpm for 20 minutes. Isolated epiphytes suspended in HCl solutions were then centrifuged at 4000 rpm for 15 minutes. Supernatants were discarded and pellets were re-suspended in 47 mm GFF filtered seawater. This procedure was repeated until most of the adhered diatoms were removed from the thalli. The final volume was adjusted to 100 ml with acidified formalin. Thalli of *P. gymnospora*were then washed and dried at 60º C to obtain constant weight.

Cell counts were made using 1 ml of preserved samples, and 700 – 900 cells were counted from each sample. Total abundance was estimated as No. X 10^5 g^{-1} Dry Weight (DW) of *P. gymnospora* thallus. Diatom samples were identified as described by Desikachary (1987) and Tomas (1997).

Statistical analysis:

Diversity indices for each sampling station were estimated using standard formulae (Shannon 1948). Cluster analysis based on Bray-Curtis similarity was done for total abundance data to estimate the similarities between diatom communities at study sites. The similarity of diatom assemblages (SIMI), in terms of the relative abundance of the epiphytic diatom taxa on *P. gymnospora*, was estimated for each sampling date by Similarity Index (Stander 1970).

Results

Hydrological parameters

Box and Whisker plots were examined for nine water quality parameters to assess spatio-temporal variations in water quality (Figure 2). pH, temperature, salinity, dissolved oxygen and suspended solids were observed to be in normal range and nearly similar at all three locations. However, biological oxygen demand and nutrient values were much higher at Mumbai than that of Malvan and Anjuna.

Species richness and diversity

A total of 53 diatom species were recorded to be epiphytic on *P. gymnospora* during its growing season (November – May). Host specimens from Malvan exhibited maximum species richness (39 spp), followed by Anjuna (37 spp) and least (28 spp) at Mumbai (Table 1). Species richness was observed to be maximum in January and February at Malvan (26 spp), while from Anjuna it was observed in November (23 spp).

Licmophora and *Biddulphia* dominated the epiphytic diatom community from Mumbai with average percentage composition of57.06% and 10.62%, respectively. *Rhizosoleniacurvata* was observed to be dominant on *P. gymnospora* from Malvan (22.86%) and Anjuna (41.38%). In Malvan and Anjuna *Navicula, Nitzschia, Grammatophora* and *Caloneis*spp were also found to be dominant during the sampling period. Epiphytic diatom community at Mumbai showed totally different distribution and abundance patterns. Significant temporal variations were observed within epiphytic diatom populations from Malvan and Anjuna. However, epiphytic community from Mumbai was dominated by *Licmophora* and *Biddulphia* throughout the study period.

Diversity indices for epiphytic diatom species at respective stations have been presented in

Table 2. Shannon Index values at Malvan and Anjuna showed rich diversity of epiphytes while at Mumbai diversity was poor.

Abundance

Maximum abundance in terms of Diatom Cells X 10^5 g^{-1} DW of *P. gymnospora* was observed at Mumbai (19.3 X 10^5 g^{-1} DW) during April. While, at Malvan maximum abundance was observed during November (.04 X 10^5 g^{-1} DW). Epiphytic diatom population at Anjuna was maximum during May (11.48 X 10^5 g^{-1} DW).

Epiphyte abundance decreased gradually from November to May, while at Mumbai it showed sudden growth from February to April. Total cell counts of diatoms on *P. gymnospora* from Mumbai were almost double than that of Malvan and Anjuna (Figure 3).

This could be attributed to higher nutrient concentrations in Mumbai waters.

Statistical analysis

Very low SIMI values obtained from diatom populations studied at Malvan (Table 3). Values close to 0 indicated diatom assemblages observed on *P. gymnosporathis* varied significantly in each month. Whereas at Anjuna and Mumbai higher SIMI values were observed, ranging between 0.3 to 0.7. Highest similarity was observed at Anjuna between samples collected during February and March. Higher SIMI values from Anjuna is attributed to occurrence of *P. gymnospora*in tide pools.

The compositional similarity studied between epiphytic diatom communities on *P. gymnospora*during different months at Malvan, Anjuna and Mumbai. The analysis of epiphytic diatom communities revealed that diatom assemblages at Mumbai are significantly different from other two locations (Figure 4). Epiphytes from Malvan as well as Anjuna formed one group indicating higher degree of similarity between epiphytic diatoms.

Discussion

Padinagymnospora, a brown algae, is the prominent form along the Indian coast. The best season for its growth from the study region has been reported during November – May (Dhargalkar et al. 2001). The present data revealed 53 epiphytic diatoms on *P. gymnospora*, which is comparatively less than the aquatic macrophytes from freshwater and brackish water habitats (Armitage et al. 2006). This could be attributed to the dynamic environment along the coast, compared to those of river and estuarine environments. Salinity, temperature and nutrient concentrations play an important role in the distribution and abundance of diatoms (Schiebel et al. 2004). Less diversity was observed at Mumbai, where nutrient values were observed to be very high. However, the maximum number of diatom species and the highest biodiversity indices were estimated from Malvan. Composition and distribution trends of diatom diversity from Malvan and Anjuna were more or less similar.

Diversity index is a measure of the biodiversity of an ecosystem, and such indices facilitate understanding the quality of the environment (Colinvaux 1973), and enable conservation and utilization of living resources by creating a single annotated index of biological collections. In general, the Shannon index falls in the range of 1.5 – 3.5 for a good diversified area, and it is considered to be zero when there is no diversity. Shannon index values of Malvan and Goa were more than three, indicating rich diversity. Similarly these two stations exhibited highly even distribution of species as evenness values of these stations were very close to one (Table 2). In contrast, though abundance on *P. gymnospora* from Mumbai was found to be relatively high, the species diversity exhibited was very low.

This could be attributed to very high levels of nutrients at Mumbai (Kulkarni et al. 2010). Though higher levels of nutrients favor diatom growth, a few opportunistic species can tolerate such ambience (deJong and Admiraal 1984). Hence, they could serve as ecological indicators. *Biddulphia*and *Licmophora*spp showed such potentials, however, further investigations are required for explicit conclusion.

Though composition of diatoms assemblages displayed wide spatial variations within all stations, well diverse communities were observed from Malvan and Anjuna. Specimens from Mumbai were found to be supportive of one species community hypothesis (Sullivan 1977).

However, entire epiphytic population at Mumbai was observed to be different from Malvan and Anjuna and this could be attributed to polluted water and occurrence of pollution tolerant species at Mumbai (Dhage et al. 2006; Sawant and Bhave 2014). Understanding dynamics of epiphytic diatom community structure would enable exploring ecological, environmental as well as bio-indicator potentials of such forms.

Conclusion

Epiphytic diatom flora on brown alga *P. gymnospora* was assessed for first time from tropical seas and total 53 species were recorded from central west coast of India. Data presented in this document will certainly be of great use to understand the spatiotemporal variability of epiphytic diatom communities. These studies revealed that epiphytic diatoms could be effectively used as bio-indicator tool; however, comprehensive studies are required for explicit conclusion.

References

Armitage AR, Frankovich TA and Fourqurean JW [2006] Variable responses within epiphytic and benthic microalgal communities to nutrient enrichment.Hydrobiologia. 569: 423 – 435.

Colinvaux PA [1973] Introduction to ecology.New York Wiley.671 pp.

Chemello R, Milazzo M [2002] Effect of algal architecture on associated fauna: some evidence from phylum mollusca. Marine Biology. 140: 981 – 990.

deJong L, Admiraal W [1984] Competition between three estuarine benthic diatom species in mixed cultures. Marine Ecology Progress Series. 18: 269 – 275.

Dere P, Karacaoulu D & Dalkiran N [2002) A Study on the Epiphytic Algae of the Nilufer Stream (Bursa). Turkish Journal of Botany. 26: 219 – 233.

Desikachary TV, Prasad AKSK, Hema P, Sreelatha M, Sridharan VT & Subrahmanyan R (1987) Marine diatoms from the Arab Sea and Indian Ocean, in: Desikachary TV (ed.), Atlas of diatoms. Fasc. IV. Madras Science Foundation, Madras. 1 – 7.

Dhage S, Chandorkar A, Rakesh Kumar, Srivastava A & Gupta I [2006] Marine water quality assessment at Mumbai West Coast. Environment International. 32: 149 – 158.

Dhargalkar VK, Untawale AG & Jagtap TG [2001] Marine Microalgal Diversity along Maharashtra coast - Past and Present Status. Indian Journal of Marine Sciences. 30: 18 – 24.

Falkowski PG, Wyman K, Ley AC and Mauzerall DC [1986] Relationship of steady state photosynthesis to fluoroscence in eukaryotic microalgae.BiochimBiophysicActa. 849: 183 – 192.

Fisher J , Dunbar MJ [2007] Towards a representative periphytic diatom sample. Hydrology and Earth Systems Science. 11: 399 – 407.

Fore L , Grafe C [2002] Using diatoms to assess the biological condition of large rivers in Idaho (U.S.A.). Freshwater Biology. 47: 2015 – 2037.

Kulkarni VA, Jagtap TG, Mhalsekar NM & Naik AN [2010] Biological and environmental characteristics of mangrove habitats from Manori creek, West Coast, India.Environmental Monitoring and Assessment. 168 (1-4): 587 – 596.

Main SP , Mcintire CD [1974] The distribution of epiphytic diatoms in Yaquina Estuary, Oregon (USA). Botanica Marina. 17: 88 – 99.

Penhale PA [1977] Macrophyte-epiphyte biomass and productivity in an eelgrass (*Zostera marina* L.) community.Journal of Experimental Marine Biology and Ecology. 26: 211 – 224.

Sawant SN, Bhave PP [2014] Impact of Pollution on Marine Environment – A Case Study of Coastal Mumbai.International Journal of Advanced Technology in Engineering and Science. 02 (07): 182 – 188.

Schiebel R, Zeltner A, Treppke UF, Waniek JJ, Bollmann J, Rixen T & Hemleben C [2004) Distribution of diatoms, coccolithophores and planktic foraminifers along a trophic gradient during SW monsoon in the Arabian Sea. Marine Micropaleontology, 51(3-4): 345 – 371.

Ranjitham N, Thirumaran G, Anantharaman P, Daisy RN & Balasubramanian R [2008] Associated Fauna of Seaweeds and Seagrasses in Vellar Estuary. American-Eurasian Journal of Botany, 1 (1): 09 – 16.

Shamsudin L, Sleigh MA [1995] Seasonal-Changes in Composition and Biomass of Epiphytic Algae on Themacrophyte*Ranunculus penicillatus* in a Chalk Stream, With Estimates of Production, and Observations on The Epiphytes of *Cladophoraglomerata*. Hydrobiologia. 306 (2): 85 – 95.

Shannon CE [1948] A Mathematical Theory of Communication.The Bell System Technical Journal. 27: 379 – 423.

Stander JM [1970] Diversity and similarity of benthic fauna off Oregon.M.Sc. thesis, Oregon State University. Corvallis. 72 PP.

Strickland JDH, Parsons TR [1972] A practical handbook of seawater analysis.Fisheries Research Board of Canada.310 pp.

Sudhakar G, Jyothi B & Venkateswarlu V [1994] Role of Diatoms as Indicators of Pollution Gradients.Environmental Monitoring and Assessment. 33: 85 – 99.

Sullivan MJ ,Currin CA [2000] Community structure and functional dynamics of benthic microalgae in salt marshes. In: MP Weinstein and DA Kreeger (Eds.), Concepts and Controversies in Tidal Marsh Ecology. Kluwer Academic Publishers, Dordrecht: 81-106.

Tomas CR [1997] Identifying Marine Phytoplankton. Ed. Carmelo R. Tomas.Academic Press.858 pp.

Ulanova A and Snoeijs P [2006] Gradient responses of epilithic diatom communities in the Baltic Sea proper.Estuarine, Coastal and Shelf Science. 68: 661 – 674.

Figure 1. Map showing sample collection locations along central west coast on India

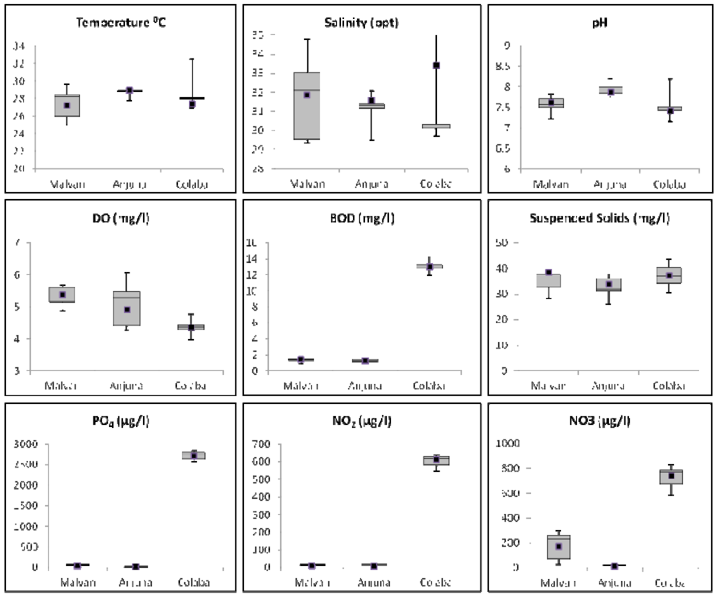

Figure 2. Physicochemical properties of marine water at study locations

Table 1. Percentage composition of diatom species found epiphytic on *P. gymnospora*

Diatom Species	Malvan	Anjuna	Mumbai
Acnanthesbrevipes	2.26	0.52	0.00
Amphora bigibba	0.37	0.00	0.00
Amphora coffeaeformis	0.48	0.09	0.00
Amphora costata	0.68	0.00	0.00
Amphora turgida	2.41	0.98	0.00
Biddulphiaaurita	0.00	0.00	0.68
Biddulphiabiddulphiana	0.00	0.39	9.94
Caloneiscrassa	0.57	0.20	0.00
Caloneis liber	2.58	0.00	0.00
Caloneiswestii	3.49	1.84	0.00
Climacospheniamoniligera	3.08	1.51	0.00
Cocconeispellucida	1.03	1.48	0.45
Cocconeispseudomarginata	0.60	1.40	0.70
Coscinodiscusasteromphalus	0.61	0.72	0.45
Cylindrothecaclosterium	0.54	0.21	0.77
Cymbellayarensis	0.74	0.00	0.50
Diatomavulgare	0.00	0.00	0.66
Diploneisnitescens	0.00	0.14	0.00
Diploneissubovalis	0.48	1.92	1.19
Fragillariaoceanica	0.00	0.00	1.77
Fragillariopsis sp.	0.00	0.00	1.76
Grammatophorahamulifera	2.45	0.00	0.00
Grammatophora marina	6.33	0.26	0.24
Licmophoraabbreviata	2.87	1.63	41.42
Licmophoraflabellata	2.42	5.42	15.64
Mastogloiafimbriata	0.50	0.59	0.00
Mastogloiaovata	0.25	3.79	0.00
Mastogloiarostrata	0.00	0.72	0.00
Melosiranummuloides	3.62	0.00	1.83
Naviculabacillum	4.28	2.79	0.00
Naviculadirecta	3.24	4.26	1.71
Naviculadisclusa	2.04	3.78	0.00
Naviculadistans	7.22	8.69	2.34
Naviculahalophila	3.72	7.01	2.30
Naviculalyra	0.69	0.00	0.00
Navicularamossisima	0.50	0.00	0.00
Nitzschiacapuluspalae	0.65	0.00	0.00
Nitzschialongissima	0.00	0.61	0.93
Nitzschiamacilenta	0.00	1.62	2.76
Nitzschiaseriata	2.45	1.55	0.00
Pinnulariaviridis	1.82	0.00	1.68
Plagiogrammainterruptum	2.11	0.00	0.00
Plagiogrammastaurophorum	3.68	0.19	0.00
Plagiotropisvitrae	0.97	0.09	0.11

Pleurosigmaangulatum	0.00	0.34	0.00
Pleurosigmaformosum	0.00	0.00	0.56
Pleurosigmagalapagense	0.62	1.06	0.27
Pseudoeunotiadoliolus	2.86	0.19	0.46
Rhabdonemapunctatum	0.00	0.39	0.00
Rhizosoleniacurvata	22.86	41.38	8.42
Synedratabulata	0.00	0.44	0.00
Trachyneisaspera	1.92	1.61	0.35
Trachyspheniaaustralis	0.00	0.19	0.11

Table 2. Diversity Indices of epiphytic diatom population

Location	Richness	Margalef Index	Evenness	Shannon Index	Simpson Index
Mumbai	17.71	1.86	0.60	1.71	0.69
Malvan	22.00	2.53	0.81	2.51	0.82
Anjuna	17.88	1.98	0.62	1.82	0.63

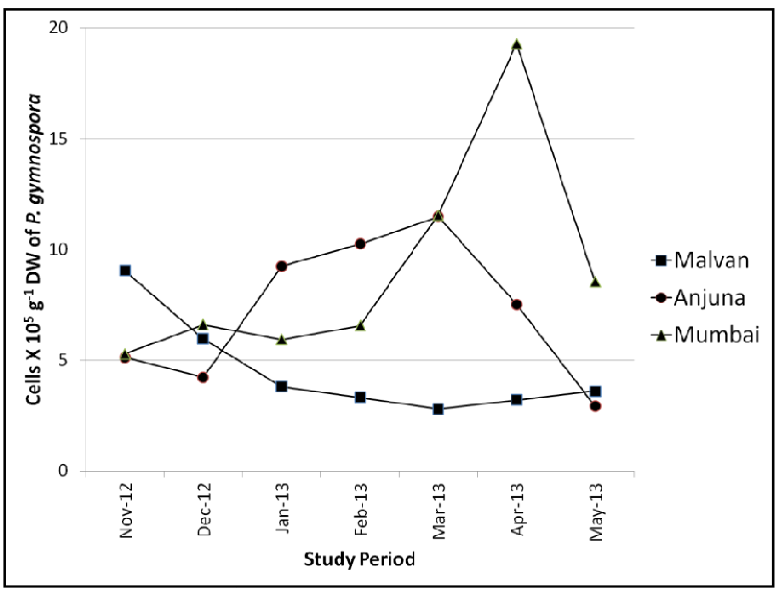

Figure 3. Cell count of epiphytic diatoms found on *P. gymnospora*

Table 3. Stander's Similarity Index showing similarity between epiphytic diatoms

Malvan						
	Nov	Dec	Jan	Feb	Mar	Apr
Dec	0.368					
Jan	0.068	0.097				
Feb	0.043	0.056	0.050			
Mar	0.027	0.029	0.027	0.037		
Apr	0.032	0.039	0.042	0.044	0.041	
May	0.041	0.035	0.042	0.040	0.036	0.038
Anjuna						
	Nov	Dec	Jan	Feb	Mar	Apr
Dec	0.049					
Jan	0.039	0.164				
Feb	0.045	0.186	0.565			
Mar	0.047	0.203	0.626	0.750		
Apr	0.049	0.167	0.498	0.596	0.663	
May	0.055	0.055	0.094	0.110	0.121	0.123
Mumbai						
	Nov	Dec	Jan	Feb	Mar	Apr
Dec	0.241					
Jan	0.265	0.240				
Feb	0.181	0.189	0.186			
Mar	0.320	0.286	0.301	0.264		
Apr	0.318	0.271	0.292	0.274	0.442	
May	0.027	0.030	0.029	0.101	0.058	0.137

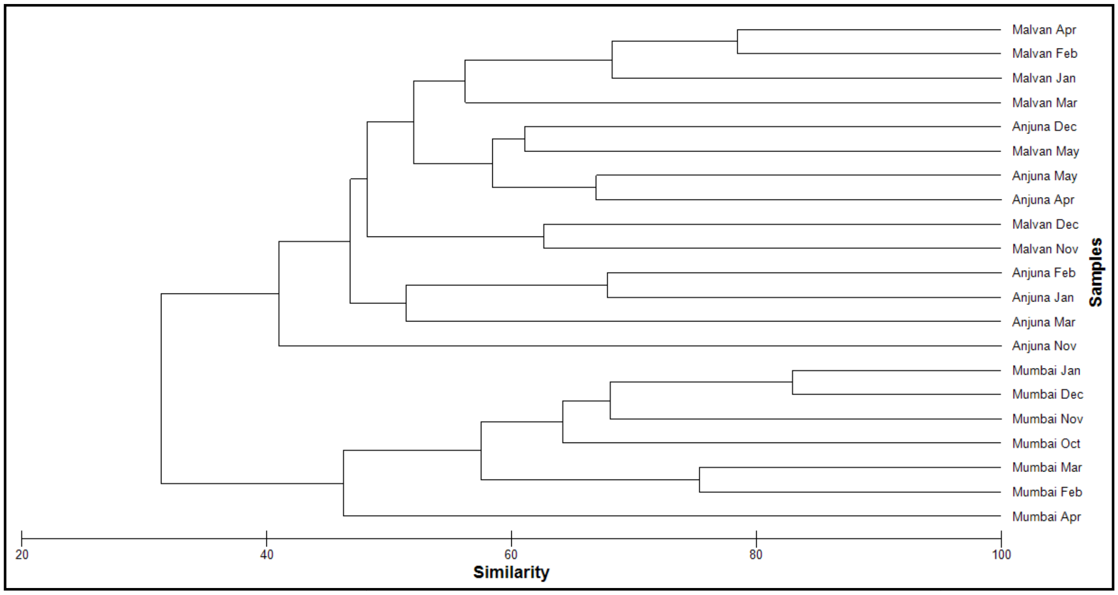

Figure 4. Dendrogram showing similarities between epiphytic diatom communities in study area

IJENAS ISSN: 2349-3763

International Journal of Environment and Natural Sciences

Website: www.ijenas.com; Email: journalijenas@gmail.com; © Centre for research in ecology, environment and social sciences (CREESS)

Experimental study on photo catalytic disinfection of moderate turbid water using granular activated carbon

Noopur Jain[1], K. Sudhakar[1]*, Yash Jain[2] & Tarun Jain[3]

[1]*Energy Centre, MANIT, Bhopal, M.P*
[2]*University of Rajasthan, Jaipur, Rajasthan*
[3]*Barkatullah University, Bhopal, M.P*

Corresponding author's E-mail: sudhakar.i@manit.ac.in

(Received: November 6, 2014; Accepted: February 4, 2015)

Abstract

The objective of this work is to assess the efficiency of solar disinfection using heterogeneous photo catalysis namely granular activated carbon. The solar disinfection process known as SODIS was considered as a reference. Activated carbon acts as photocatalyst for temperature enhancement and as adsorbent for reducing turbidity by adsorbing sediments and volatile organic compounds. It has been found that turbidity got reduced up to 71% and there was a temperature difference of 5°C in the sample with and without activated carbon. Results showed that the choice of catalyst (granular activated carbon in this study) was also an important factor for disinfection using sunlight. This demonstration opens the possibility of application of this simple method for water treatment in rural areas of developing countries.

***Keywords**:* Photocatalysis, granular activated carbon, adsorbent, turbidity, solar

Introduction

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. At present, 768 million people, lack access to a safe and reliable source of water and over 2.5 billion lack accesses to adequate sanitation [1].As the world is already staring at impending water crisis due to climate change, population increase and pollution, a UN report has predicted that as many as 3.4 billion people will be living in "water-scarce" countries by 2025.It was also pointed out that the situation will be deteriorated further in the next 25 years (by 2050), culminating into instances of human conflicts in many parts of the globe. The report, published on the eve of the World Water Day, indicated that the Indian sub-continent may face the brunt of the crisis where India would be at the Centre of this conflict due to its unique geographical position in South Asia [2].

India has 18% of the world's population; it has 4% of water resources of the world [3]. Reports according to Cofie et al (2003) also indicate that 90% of water in India is polluted;

it may not be an overstatement that most surface water in developing countries remains suspicious in terms of quality [4]. Every year, 1.8 million people, mostly in developing countries, die of diarrhoea, 90%are children under the age of five. This is equivalent to about 4500 children dying every day [5].The ever-increasing prevalence of endemic diseases like diarrhoea, dysentery, amoebiassis hepatitis, typhoid; Jaundice etc. may be suggestive of the severe exposure to harmful effects of water pollution in developing countries.

Today, the biggest problem in the rural areas of India is lack of drinking water. In India, women used to bring drinking water after walking several miles daily as most of the water resources have been polluted and ground water level has also been decreased. So, in order to solve this problem, the government of India has initiated and implemented many schemes &programmes like Rajiv Gandhi National Drinking Water Mission. Public water supplies in developing countries often fail to produce and distribute water safe for consumption. Even if safe water is provided at the source, transport, storage and handling of water often lead to secondary contamination before consumption. Point of use water treatment methods are therefore gaining increased significance with regard to reducing the global diarrhea burden [6].

SODIS (solar water disinfection) is one of the best options for purification of water mainly in tropical countries and India being a tropical country, have abundance of sunshine almost all round the year. To overcome the problems of incomplete disinfection under weak and moderate weather conditions, some simple techniques are used in this study, including addition of granular activated carbon to increase SODIS efficiency by increasing temperature at much faster rate.
The objectives of the study are-

- To investigate the ability of granular activated carbon to heat water in the SODIS system.
- To find out the turbidity removal efficiency of granular activated carbon.
- To find out the optimum amount of activated carbon needed to get the best result for moderate turbid water.

Materials and methods

Source of samples:The area of the study selected, to estimate the water quality and levels of water pollution, is the Shahpura lake of Bhopal city. It is located in the southern part of the city. It is manmade reservoir formed in 1974-75, under the Betwa irrigation project. The waste water inflow keeps the lake perennial and the over flowing water flows through a nala to join kaliyasot river which flows into river Betwa. The degradation of lake has occurred not only due to waste water effluent inflow but also by saltation, domestic sewage, immersion of idols and other activities around the lake. Thus, the lake is subjected to enormous anthropogenic stress; the overall impact has resulted in the deterioration of the water quality, accumulation of toxic chemicals and sediments, shrinkage of lake area and above all, loss of the aesthetic value.

Photocatalyst: Granular Activated Carbon is a form of activated carbon with a high surface area which adsorbs many compounds including many toxic compounds.

Experimental procedure

The physio-chemical parameters of water samples are measured before treatment with photo catalyst.Five pet bottles of one litre were filled with same water source. Photocatalst with different amounts are added in the PET bottles: 2.5g/l of activated carbon in bottle 2, 5.0g/l in bottle 3,10g/l in bottle 4 and 15g/l in bottle 5 are added. The bottles are placed on the iron stand as shown in Fig.2 and these are exposed to natural sunlight, specific to weather patterns in Bhopal, M.P, India (23° 16' N, 77° 36' E).The experiment was conducted on a sunny day between 10.00 and 15.00 h.Turbidity and temperature were measured after every hour.

Analysis: The physiochemical parameters of water sample from Shahpuralake were measured using TDS meter, Turbidity meter and pH Meter. The ambient temperature was measured using digital thermometer. The incident solar radiation was measured using a solar power meter .The specifications of the instruments used for testing water samples are listed in Table 1.

Results and discussions

Physio-chemical properties of Betwa water sample

The various parameters were measured and the initial water parameters are listed in Table 2.

Weather characteristics

SODIS efficiency depends on geographical location and amount of solar radiation .These weather parameters are measured at Energy Centre, MANIT, Bhopal, M.P, India (23° 16' N, 77° 36' E) on 22/5/2014. Ambient temperature varied from 41.2 to 44.0 ℃. A maximum temperature of 44.0℃ was recorded on the day of experiment. Solar radiation intensity varied from 1410 to 1540 W/m^2. Maximum intensity recorded on that day was 1540 W/m^2. The variations in solar intensity and ambient temperature are presented in Fig.8 & Fig.9. Higher the ambient temperature and solar intensity, higher will be the SODIS efficiency.

Water quality parameters

Turbidity: Turbidity got reduced in all the samples, but in sample bottle 1 without activated carbon, the decrement rate was very slow as compared to other samples with activated carbon. In sample 4(10g/l) and sample 5(15g/l), turbidity initially increased just after the addition of activated carbon and then decrement was observed. Sample 2(2.5g/l) was having the minimum turbidity when compared to all the samples at 3pm as shown in Fig.10. In sample 2(2.5g/l) turbidityreduced up to 71.4%.

Temperature: Temperature increased in all the samples but in sample 1(without activated carbon).The increment rate was very slow as compared to all other samples with activated carbon. In samples with activated carbon, water temperature reached to 55℃ in just 2hours while in sample 1 (without activated carbon), water temperature reached 50℃ in 4hours of experiment. At 3pm, the temperature of sample 5(15g/l) and sample 1(0g/l) was 58.9℃ and 51.4℃ respectively. So, it can be seen clearly that there was a temperature difference of almost 8℃ as shown in Fig.11.

Conclusion

Activated carbon was used as photo catalyst in SODIS to reduce the treatment time. Samples treated with activated carbon, reached 55℃ water temperature in just 2hours while sample without activated carbon, took 4 hours to reach water temperature of 50℃.It has been found that in sample 2 (2.5g/l), turbidity reduced up to 71% and there was a temperature difference of 5℃ in the sample 2 (2.5g/l) and in sample without activated carbon. So, activated carbon could be a better option in rural areas in order to increase SODIS efficiency and reduce the required time. Activated carbon not just acts as photo catalyst but also reduces the turbidity of water and adsorbs many compounds including many toxic compounds. This could be an alternative for water disinfection in rural areas of developing countries, where other disinfection practices can hardly be applied.

References

Reports *of India's ministry of water resources,*

Reports *of World Bank,*

Reports of UNICEF and cse

K. A. Yongabi,Biocoagulants for Water and Waste Water Purification: a Review

WHO, Database on Water, Sanitation, Hygiene, 2004.

L. Fewtrell, R.B. Kaufmann, D. Kay, W. Enanoria, L. Haller and J.M. Colford Jr., Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis, Lancet Infect. Dis., 5 (2005) 42–52.

Alejandra Martı´n-Domı´nguez, Ma. Teresa Alarco´n-Herrera, Ignacio R. Martı´n-Domı´nguez, Arturo Gonza´lez-Herrera, Efficiency in the disinfection of water for human consumption in rural communities using solar radiation.

R. Meierhofer,MartinWegelin, SOLAR WATER DISINFECTION-A guide for the application of SODIS

Figure 1: Granular Activated Carbon

Figure 2: Samples with activated carbon

Table 1. Specification of Instruments

S.No	Name of the Instrument	Make/Model	Range
1	Turbidity meter	Hach 2100 Q,USA	0-1000 NTU
2	EC/TDS	HI2300,Hanna ,USA	1-1999 ppm
3	Bench pH meter	HI2211,Hanna ,USA	0 to 14 pH
4	Digital Temperature	H-9231A,Hanna,USA	-50 + 300º C
5	Solar Power meter	Tenmars,TM -207,Taiwan	0-1500 ^{2}

Figure 3: EC/TDS/NaClmeter

Figure 4: pH Meter

Figure 5: Turbidity Meter

Figure 6: Digital Thermometer

Figure 7: Solar Power meter

Table2. Initial parameters

Turbidity	28.2 NTU
pH	8.25
Electrical conductivity	606 µS
TDS(Total dissolved solids)	303 ppm
Temperature	32.1℃
% Nacl	1.2
ORP(Oxidation reduction potential)	-72.7mV

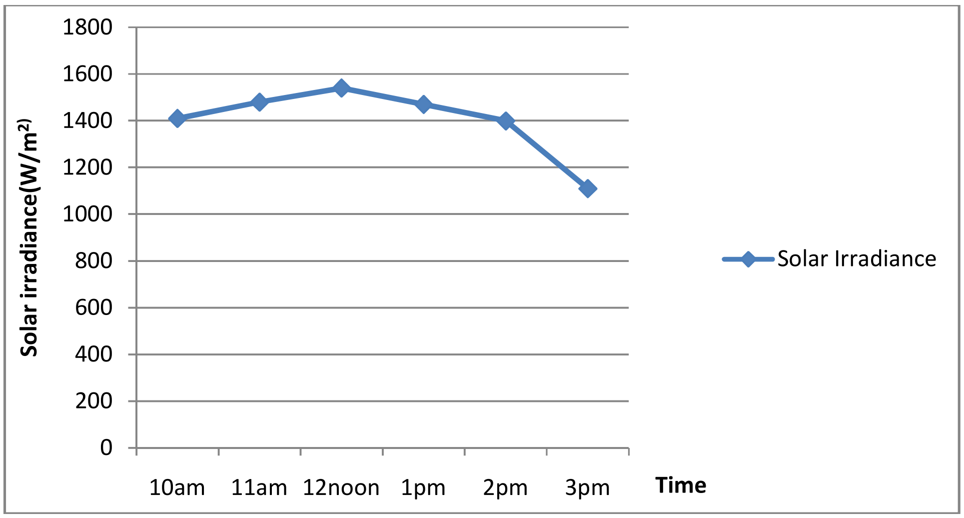

Figure 8: Variation of solar intensity with time

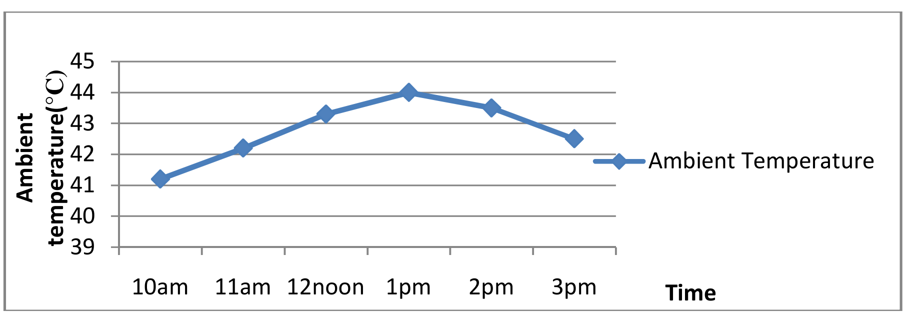

Figure 9: Variation of ambient temperature with time

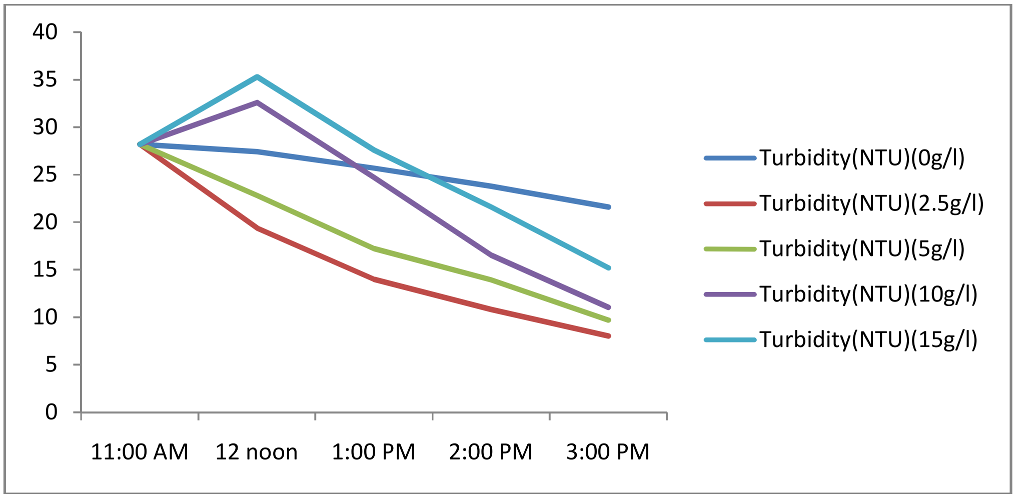

Figure 10: Variation of Turbidity with Time

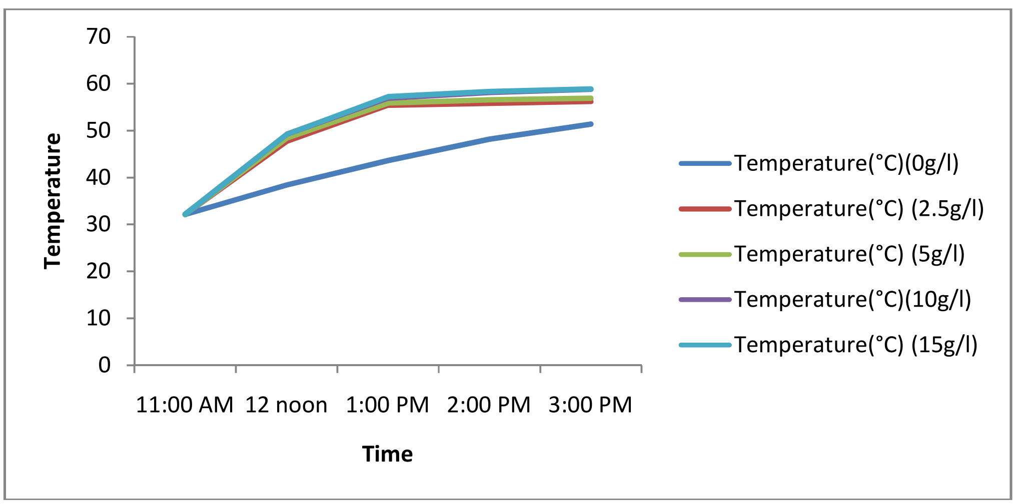

Figure 11: Variation of Temperature with Time

ISSN: 2349-3763

IJENAS

International Journal of Environment and Natural Sciences

Website: www.ijenas.com; Email: journalijenas@gmail.com; © Centre for research in ecology, environment and social sciences (CREESS)

Dispersion Modeling for Air Pollutants Emitted from a Common Incinerator Facility and its Impact Assessment

Awadhesh Kumar[1*], Chandralekha Bharti[2], & Rakesh Shah[3]

[1]*Sr. Environmental Engineer; Engineering & Design Section, Anand Environmental Consultants (P.) Ltd., Ahmedabad-13.*
[2]*Sr. Environmental Engineer; Engineering & Design Section, Anand Environmental Consultants (P.) Ltd., Ahmedabad-13.*
[3]*Chief Chemical Engineer & Director, Anand Environmental Consultants (P.) Ltd., Ahmedabad-13.*

*****Corresponding author's E-mail: awi.mmmec@gmail.com*

(Received: September 15, 2014; Accepted: November 4, 2014)

Abstract

Climate change is a global issue in which diverse environmental factors contribute, the air pollutants emissions generated from the incineration of industrial wastes can one of them. Various type of air pollutants emissions during operation of waste incineration. It is essential to monitor the advance waste incinerator in order to comply, stipulated pollutants emission limits as prescribed by EPA/ CPCB for waste incineration facility. Incinerators associated with best available technology releases only trace amount of chemicals to environment with respect to conventional incinerators even though there is no definite evidence that can render null health effects. Air quality dispersion modeling can be a link between air emissions from incineration activity in it's vicinity and resultant air concentrations. This paper presents a practical and usable methodology, facilitating a bottom-up model to get detailed emission inventory that includes emissions dispersion for incinerator facility by applying mathematical model namely "Industrial Source Complex Short Term (ISCST-3) Dispersion Model", developed by USEPA and its impact assessment in closest vicinity /zone. It is a decision making tool in ambient air quality, to the identification of its likely impact on environment. Also, assisting to provide for uniform benchmarking as well as in the determination of stack (chimney) location, stack design, ambient air monitoring network design and selection of alternatives.

***Keywords**: Incinerator; Pollutants; Meteorology; ISCST-3; Modeling; Impact assessment*

Introduction

The role of waste incineration varies across the globe. The waste quantity incinerate in waste incineration facility can very high volume in developed / industrialized countries viz. USA, Japan, Europe and Canada etc, while in most developing countries like India, Pakistan etc. land-filling is the more common waste management practice. The assessments of the air pollutants on health and environmental impact based on fact that incinerators associated with best available technology (BAT) which make contribution in trace amount to surrounding environment.

Applications to build and operate incinerators invariably include an assessment of probable emissions to air environment (The Health Protection Agency 2009). Thus, quantitative estimation of air pollutants emission will necessary. Air is a main constituent of the environment that must have better air quality in surrounding the point source, can be better estimated / predicted with the help of Air Dispersion Modeling (Central Pollution Control Board 1998)**.** The nonlinear model based on inverse relationship of pollutants concentration with wind speed and sine and cosine of wind direction is used to obtain one-step ahead forecast (Sargam Mishra, et al. 2011).

The present practice for ambient air quality predictions is through application of Gaussian Plume Model and its available variations. The experience so far, has shown that the values of parameters are often adopted from other countries without understanding their applicability in Indian context. In this context approach made for the characterization of ambient air pollutant concentrations at an urban scale with application of dispersion model, such as the U.S. Environmental Protection Agency (USEPA) regulatory model (ISCST), which can simulate large (Rich Cook,et.al 2008)**.** Modeling results show substantial heterogeneity of pollutant concentrations within the model for pollutants dominated by direct emissions. The inverse relationship between wind speed and pollutant concentrations up to some threshold is established in the many studies (R.M. Harrison, J. Yin, D. Mark, J. Stedman, R.S. Appleby, J. Booker, S. Moorcroft 2001; M. Aldrin, I.H. Haff 2005). With the help of air dispersion models ground level concentrations can be predicted for a period of time, space from any point source, multiple source, line source, area source and volume source. It requires input data like intensity of source, pollutant type for a prescribed source as well as meteorological parameters, atmospheric stability, stack details, topography, terrain of the area and so on so forth (Dr.Akshey Bhargava, Payal Patel 2011).

Air dispersion model is a mathematical expression which estimates concentration, release, disperse, transport and transformation of pollutants in the environment. It also provides/ performs computer aided programs for extent of dispersion of pollutants.

These dispersion models require details about emission rates of the pollutants and the local meteorology conditions of the region and its topography (Air Policy Section Alberta Environment and Sustainable Resource Development, Edmonton, Alberta 2013). In order to meets ambient air quality it is necessary to estimate/predict the ground level concentration (GLC) value for a point sources emission within various specified distance.

The environmental impacts of a projects or actions generally encompass a broad range of impact from air pollution to effects on employment and neighborhood as well as social structure. All of these impacts vary in magnitude as well as their beneficial or adverse classification. The impacts on air quality from any project depends on various factors like design capacity, configuration, process technology, feed materials, envisaged emissions control measures, operation and maintenance practices.

Materials and Methods

Data Collection of Study Area: The upcoming incinerator to be installed in the West part of India i.e. Dholka area of district Ahmedabad, with its geographical location is Longitude- 72º 19 'E, Latitude-22º 27' N.

Meteorology

Meteorological conditions of the site help in determination of emission of pollutants in a prevailing wind direction and wind speed. Another meteorological factor which affect the transport and diffusion of air pollutant are ambient temperature, atmospheric stability etc.

Ambient temperature: The ambient temperature was recorded in the range on 27.6 – 39.2 °C during the monitoring period.

Wind Speed and Wind Direction: The results of wind speed monitoring were in the range of 3.5-14.8 Km/hour during the monitoring period. Wind speed and direction data were collected using the Wind Monitor-WM 300 data for the Summer Season and also used Indian Meteorological Department (IMD) data for Ahmedabad city details are as depicted in Figure-A and Figure- B.

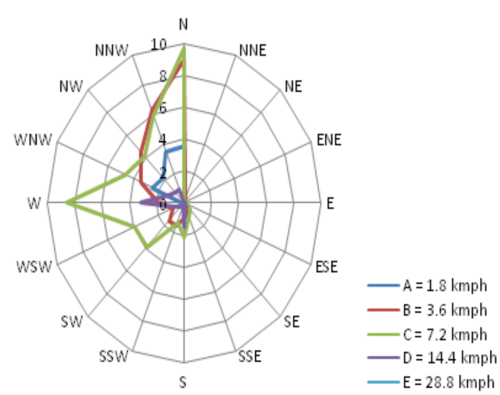

Figure- A

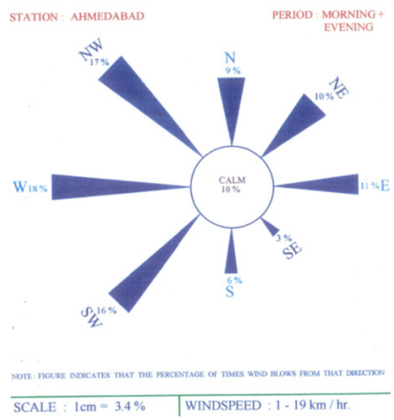

Figure- B

Secondary Meteorological Data: The data for secondary meteorological parameters viz. relative humidity (%), rainfall, pressure, cloud cover and visibility have been taken from Book of Climatological Tables of Observatories in India 1951 – 1980 (India Meteorological Department1951–1980). The above stated secondary meteorological parameters indirectly regulate the air pollutants dispersion by affecting primary meteorological parameters.

Atmospheric Stability and Mixing Height: Atmospheric stability is highly dependent upon the vertical distribution of temperature with height, whereas atmospheric stability class- C (slightly unstable) was used and the mixing height (MH) values showed gradual increase after sunrise, reached to maximum in the afternoon and then decreased gradually till night in all the season, the value of mixing height was taken in account sourced from IMD Ahmedabad Station (S.D.Attri, Siddhartha Singh, B. Mukhopadhyay, A.K. Bhatnagar 2008).

Characteristic of Terrain Level: The location is in rural area and having flat terrain level was taken in consideration.

Overview of Modeling Options: By using this mathematical model, impact on air quality emission from a single and or group sources is evaluated. The air pollutants emitted from a source immediately get dispersed in to the environment through wind. Air quality model is designed to assume this process mathematically, to know the relation between primary pollutants emissions and downwind air quality.

In the present case ISC-3 (industrial Source Complex) model has been used to predict the air impacts. Impact ISC-3 models for stack uses the steady state Gaussian plume equation.

Dispersion Options- The Industrial Source Complex model is designed to facilitate the regulatory Modeling programs of EPA, which admit the use of stack-tip down wash, buoyancy-inducted dispersion, final plume rise;

Source Options- Multiple sources; point source, volume source, area source and open pit source types can be handle by this model.

Receptor Options- This model has flexibility in the specifying place/coordinates of receptor. It also specifies the place of the polar receptor origin, in addition of the default origin at (0,0) in x,y, coordinates,

Meteorology Options- The model commissioned the all useful meteorological parameters in the specified input file in ASCII format.

The features of this model: Stimulates dispersion from single/multiple/area/line volume sources; Allows calculations to be made at a user specified regular rectangular grids; Provides estimates of concentration for any averaging time period for entire period of input meteorology; Allows calculation to be underwritten for sources groups as selected by the user; Uses Briggs dispersion curves as selected by the users to derive the plume spread parameters; Adjusts fro wind speed variation with height, using user specified default urban /rural power law coefficient; Stimulates dispersion from buoyant, non buoyant point sources, non buoyant area, non buoyant volume sources and non buoyant line sources; Uses Briggs' plume rise algorithm to calculate plume height.

The basic principle of this model having basis that the air pollutant emissions from a point / stationary sources to be transported and dispersed after its discharge**.** The atmospheric dispersion of pollutants governs by the following process:

- An initial vertical rise called the plume rise (due to buoyancy and momentum of discharge).
- Dispersion by turbulence in wind in horizontal and vertical direction
- Adequate transport by wind in its direction.
- Gravitational Settling - significant for particles of size greater than about 10 µm;
- Chemical reactions and decomposition;
- Deposition on vegetation and other surfaces;

- Wash out due to rain;
- A combination of complex physical and chemical processes, i.e. coagulation of particles, desorption of deposited vapors, etc.

Air Dispersion Model Used: A

$$X = -(XR) - X(S)) \text{ Sin } (Wd) - (Y(R) - Y(S) \text{ Cos } WD)$$
$$Y = (XR) - X(S)) \text{ Cos } (Wd) - (Y(R) - Y(S) \text{ Sin } WD)$$

mathematical model namely *"Industrial Source Complex Short Term (ISCST-3) Dispersion Model", developed by USEPA* was used to predict and calculate Ground Level Concentrations (GLCs) of the pollutants emitted during operational phase. This is based essentially, on the original Gaussian Plume Model equation but is defined in terms related to atmospheric phenomenon.

Gaussian Plume Model: The ISC Short Term model to be used to predict the point source (stack) emissions and isolated vents for a elevated source on continuous basis. The origin of the sources coordinates system to be

$$U_s = U_{10} (Hs/10)^p \quad \text{...eq.3}$$

fixed at the base of the stack on ground surface for each source / hour. The 'x axis (positive) in downwind direction**;** the 'y' axis is crosswind (normal) to 'x' axis and the 'z' axis extends vertically. To calculate of each hourly concentration, the fixed receptor location is to be converted to coordinate system of each source. The calculated concentration of each hour for each source at each receptor added to get the entire concentration by combined source emission. For this model, the concentration for each hour at downwind and crosswind distances i.e., x (m) and y (m) respectively can be obtained with the application of the equation as stated under:

Where,
X: Concentration of pollutant at a point (x, y); (g/m^3)
Q: Source strength (Pollutant Release Rate); (g/s)
u: Horizontal wind speed at the source level; (m/s)
Sy&Sz: Vertical & Horizontal crosswind dispersion coefficients respectively, which are a function of downwind distance 'x' and atmospheric stability; (m)
K: Scaling coefficient; to convert estimated concentrations to a desired unit
D: Decay term and

Vertical Term (V)
Where,
He: Effective release height of emission (plume rise + physical stack height)
Hm: Mixing height
γ : reflection coefficient

Complete reflection from earth surface has been assumed (γ=1). The above equation is single source. For number of sources more than one stimulation is done for each individual source and then added. In order to

$$X(x, y, z) = \frac{Q\,K\,V\,D}{2\,\pi u S y S z} \exp\left[-0.5 \left(\frac{y}{\sigma y}\right)^2\right] \quad \text{.....................eq.1}$$

calculate σ_z and σ_z for various receptors points down wind distance is desired for given wind direction in order to calculate downwind distances following equation are used.
Where,
X(R) , Y(R) are receptors point coordinates,
X(S) , Y(S) are source coordinates,
WD is wind angle from north.

Wind Speed at Stack Level: To adjust the observed wind speed at 10 m height to the stack of release height (Hs) , the wind power law to be used. The power law equation to calculate wind speed at stack height is of the

$$Hpr = 1.6\, F^{1/3} (X)^{2/3} / U \quad \text{..................................eq.5}$$

following equation form.

Where,
U_s :Wind speed at stack level (m/s)
U_{10}:wind speed obtained from automatic weather wind monitor (WM-300) in (m/s)
Hs : Physical stack height
p : Wind profile exponent; values for stabilities A, B, C, D, E & F are 0.07, 0.07, 0.10, 0.15, 0.35, and 0.55 respectively

Effective Stack Height : The effective stack height, He, to be used in Gaussian equation is

$$He = Hs + Hpr \quad \text{..eq.4}$$

given:
Where,
He = Plume rise (m) due to thermal and momentum factors
Hs = Effective stack height
Hpr= Physical stack height

Plume Rise: In the present case plume rise has been calculated by Briggs' formula (1975). The details of this equation are given below;

Plume rise under unstable and neutral conditions:

(a) Buoyancy dominated

Where

$$V = (1+\gamma) \exp -\frac{He^2}{2\sigma_z^2} + \sum_{i=1} \gamma \exp -\frac{(2n\,Hm - He)^2}{2\sigma_z^2} + \frac{(2nHm+He)^2}{2\sigma_z^2} \quad \text{.........eq.2}$$

$x \le 3.5\, x^*$ and
$x^* = 14\, F^{5/8}$ if $F < 55\ m^4/sec^3$
$= 34\, F^{2/3}$ if $F \ge 55\ m^4/sec^3$

In present computations x is taken equal to 3.5 x*, for this value of x maximum plume under unstable and neutral conditions is governed by the following simplified equations:

$$Hpr\ (max) = \underline{21.425\ F^{0.75}}\ ;\ F < 55\ M^4/sec^3 \quad \text{...............eq.6}$$

$$= \frac{38.71\ F^{0.60}}{U}\ ;\ F < 55\ M^4/sec^3 \quad \text{...............eq.7}$$

Where,
$F = gVs\ (Ds/2)^2\ [(Ts-Ta)/Ts]$
$g = 9.81\ m/s^2$
Vs = Stack gas velocity (m/s)
Ds = Stack diameter at top (m)
Ts = Stack Gas Temperature (°K)
Ta = Ambient Temperature (°K)

(b) Momentum dominated plume rise under unstable and neutral conditions:

$$Hpr\ (max) = 3\ ds\ (Vs/U);\ Vs/U>4 \quad \text{...............eq.8}$$

Determination of dominance of buoyancy or momentum under unstable and neutral conditions:

First ΔT and (ΔT)c are calculated by following equations;

If Ts> Ta and ΔT>(ΔT)c assumed plume rise

$$\Delta T = Ts - Ta \quad \text{...............eq.9}$$

$$(\Delta T)c = \frac{0.0297\ Ts\ Vs^{1/3}}{Ds^{2/3}}\ ;\ F < 55\ M^4/sec^3 \quad \text{..............eq.10}$$

$$= \frac{0.05757\ Ts\ Vs^{1/3}}{Ds^{2/3}}\ ;\ F \geq 55\ M^4/sec^3 \quad \text{..............eq.11}$$

is buoyancy dominated and
If Ts <Ta and ΔT<(ΔT)c plume rise is momentum dominated .

Plume rise under stable weather conditions:

(a) Buoyancy dominated plume rise

$$Hpr = 2.6\ (F/US)^{1/3} \quad \text{...............eq.12}$$

Where,
U = wind velocity at stack level (m/s)
S = stability parameters
$S = \frac{g}{Ta}\ \frac{\partial\theta}{\partial Z}$
$\frac{\partial\theta}{\partial Z}$ = temperature gradient
$\frac{\partial\theta}{\partial Z}$ = 0.02 for stability E
= 0.035 for stability F

(b) Momentum Dominated plume rise:

(c) Dominance of momentum or buoyancy for plume rise under stable weather condition:

If Ts> Ta and ΔT>(ΔT)c assumed plume rise is buoyancy dominated and

If Ts <Ta and ΔT<(ΔT)c plume rise is momentum dominated .

Determination of Plume rise under calm condition (wind velocity at 10 m less than 2 kmph)

In case of calm winds plume rise is calculated by eq.14 and following equation and the lower value of two is taken as final plume rise.

$$Hpr = 4\ F^{1/4}\ S^{-3/8} \quad \text{...............eq.15}$$

Atmospheric Stability

$$Hpr = 1.5\ \left[\frac{Vs^2}{4}\ \frac{Ds^2}{T}\ \frac{Ts^{-1/3}}{U}\right]\ S^{-1/6} \quad \text{...............eq.13}$$

Many alternatives models are developed by different authors to relate σy & σz with downwind distance x under different atmospheric stability conditions. Unfortunately none of these have been found to be comprehensive enough Table- 1**.**

Table-1: Pasquill–Gifford stability classification (SC)

Surface wind speed (m/s)	*Day time insoltaion*			*Night time condition*	
	Strong	*Moderate*	*Slight*	*Thin low clouds <4/8*	*Overcast clouds >3/8*
0 – 2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	D	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

Where,
A:Extremely Unstable; **B:**Moderately Unstable; **C**:Slightly Unstable; **D**:Neutral; **E**:Slightly Stable; **F**:Moderately Stable

Dispersion Coefficient

In the present computation the dispersion coefficient proposed by **Briggs' for open country** has been used.

Theses dispersion coefficient are valid up to 10km distance from polluting sources. The equation is given Table-2.

Table- 2 : Briggs' dispersion parameters σy (m) & σz(m) (100 M < x <1000 m) Rural Conditions

SC	*σy (m)*	*σz(m)*
A	$0.22 \times (1 + 0.0001x)^{-0.5}$	0.20x
B	$0.16 \times (1 + 0.0001x)^{-0.5}$	0.12x

$$(\Delta T)c = 0.01958\ Ta\ Vs\ S^{1/2} \quad \text{...............eq.14}$$

C	$0.11 \times (1 + 0.0001x)^{-0.5}$	$0.08 \times (1 + 0.0002x)^{-0.5}$
D	$0.08 \times (1 + 0.0001x)^{-0.5}$	$0.06 \times (1 + 0.00015x)^{-0.5}$
E	$0.06 \times (1 + 0.0001x)^{-0.5}$	$0.03 \times (1 + 0.0003x)^{-0.5}$
F	$0.04 \times (1 + 0.0001x)^{-0.5}$	$0.016 \times (1 + 0.0003x)^{-0.5}$

Basic Input Data Requirements For ISCST-3 Modeling Software

The X-axis is positive to the east of the user-specified origin and the Y-axis is positive to the north in Cartesian coordinate system. Cartesian coordinates will be used to locate receptor network in ISC model. The ISC model is designed to have 500 receptors, 100 sources, 2 source groups and 2 numbers of short-term averages.

Input Options: The basic input data requirements for EPA ISCST-3 Modeling software are as presented in Table- 3.

Table- 3 : Basic input data requirements for Modeling software

Input data requirement	*Source of data*
Average time for a particular run	8 hrs & 24 hrs
Name of pollutants	Identified from source/ manufacturing process / industrial information
Stack emission rate (g/s)	Maximum allowable as per EP Act or measured or as per unit
Stack height (m)	As per unit
Exit velocity (m/s)	As per unit / measured
Stack diameter (m)	As per unit / measured
Stack exit temperature(°C)	As per unit / measured
Wind direction	Obtained using meteorological instrument namely WM 300 mfg. by M/s Enviro – Tech Instruments P Ltd., Delhi
Wind speed (m/s)	
Ambient temperature(°C)	
Standard deviation (deg)	
Rural/Urban mixing height (m)	Obtained from IMD station where data is available /by Sodar

Flue gas stack's emissions: Details of the common incinerator stack are given in Table- 4. The said incinerator will be operated / maintained as per the CPCB guidelines for Common Hazardous Waste Incinerator.
Common Incinerator facility will be used to incinerate approximately 740 m³/day of liquid waste/industrial wastewater and 4.5 MT/day of hazardous wastes generated from the various chemical manufacturing units. The details of expected pollutants emissions used for evaluation of ground level concentration (GLCs) are given in Table- 5

Table- 4: Details of stack attached to common incinerator facility

Stack height from G.L.	*Stack diameter at the top*	*Fuel consumption rate*	*Flue gas velocity*	*Flue gas temp.*	*Air pollution control system*
45 m	0.45 m	Oil - 80 m³/day	8 m/s	343^oK	Scrubber

Table- 5: Data used for the evaluation of GLCs

Parameters	*Concentration of pollutants in mg/m³*	*Pollutant emission rate [Max.] in kg./hr.*	*Pollutant emission rate [Max.] in g/sec*
PM	50	0.22890	0.06358
HCl	50	0.22890	0.06358
SO2	200	0.91562	0.25435
CO	100	0.45781	0.12717
TOC	20	0.09156	0.02543
HF	4	0.01830	0.00508
NOx	400	1.83125	0.50868
Total Dioxins & Furans	0.1 ng (TEQ) / Nm³	0.00000000457	0.00000000127
Cd	0.05	0.0002268	0.000063
Th	0.05	0.0002268	0.000063
Hg	0.05	0.0002268	0.000063
Sb	0.5	0.002286	0.000635
As	0.5	0.002286	0.000635
Pb	0.5	0.002286	0.000635
Cr	0.5	0.002286	0.000635
Co	0.5	0.002286	0.000635
Cu	0.5	0.002286	0.000635
Mn	0.5	0.002286	0.000635
Ni	0.5	0.002286	0.000635

Parameters	Concentr-ation of pollutants in mg/m³	Pollutant emission rate [Max.] in kg./hr.	Pollutant emission rate [Max.] in g/sec
V	0.5	0.002286	0.000635

Results and Discussion

Output results for EPA ISCST- 3 Modeling software which includes various details as described under;

- Summary of 1st / 2nd highest of 8 hrs. average concentration values at various distance from source in different directions.
- Summary of 1st / 2nd highest of 24 hrs. average concentration values at various distance from source in different directions.
- Summary of overall maximum value for 8 hrs. average periods as well as for 24 hrs. average periods and their locations.
- Summary of total period average concentration values at various distances from source in different directions.
- Summary of first six highest of total period average concentration and their locations.

Details of cumulative ground level concentration derived from ISCST-3 dispersion model from the common incinerator stack the maximum evaluated 24 hrs GLCs in microgram/m³ for different pollutants viz. PM (1.6040 µg/m³), HCl (1.6040 µg/m³), SO_2 (6.4168 µg/m³), CO (3.2083 µg/m³), TOC (0.6416 µg/m³), HF (0.1283 µg/m³), NOx (12.8330 µg/m³), Total Dioxin (0.0000 µg/m³), Total Furan (0.0000 µg/m³), Cd (0.0016 µg/m³), Th (0.0016 µg/m³), Hg (0.0016 µg/m³), Sb (0.1605 µg/m³), As (0.1605 µg/m³), Pb (0.1605 µg/m³), Cr (0.1605 µg/m³), Co (0.1605 µg/m³), Mn (0.1605 µg/m³), Ni (0.1605 µg/m³), V (0.1605 µg/m³), (Figure- C).

Air quality contours were prepared by using software (SURFER) which requires ISCST-3 outfall data, meteorological data and stack's details for the various pollutants are as depicted in the Figure- D to Figure- I.

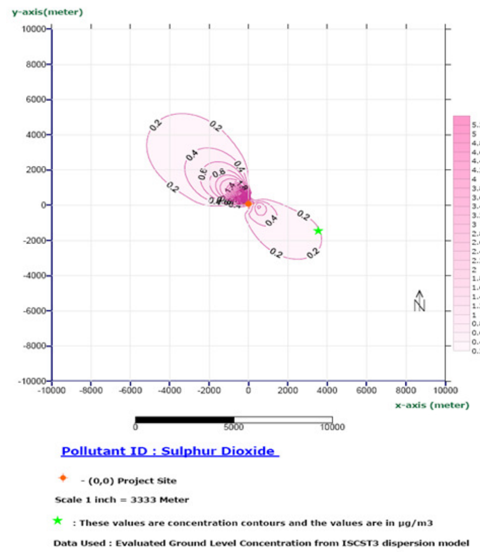

Figure- C

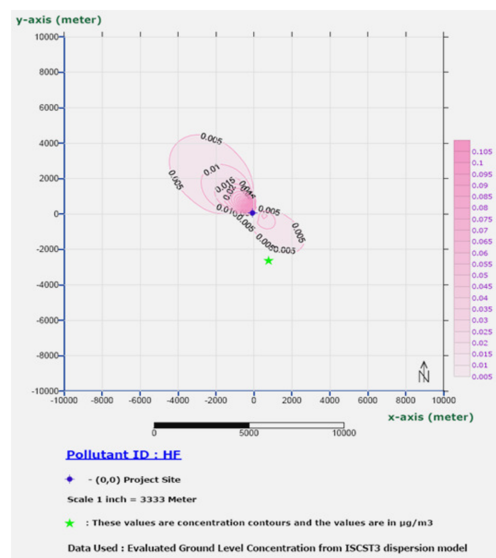

Figure- D

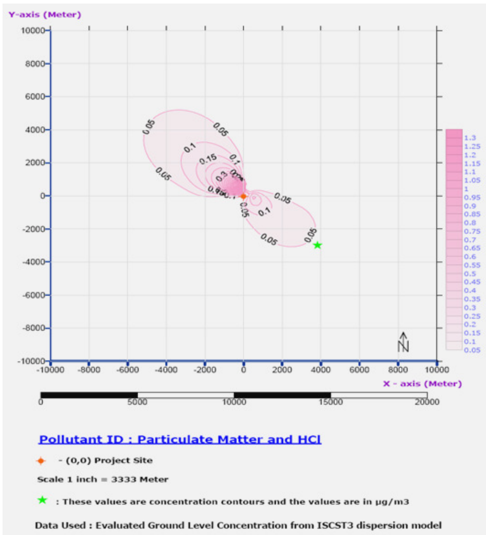

Figure- E

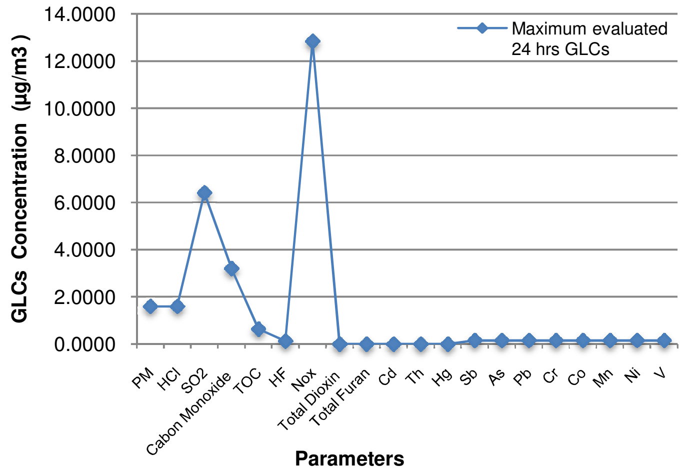

Figure- F

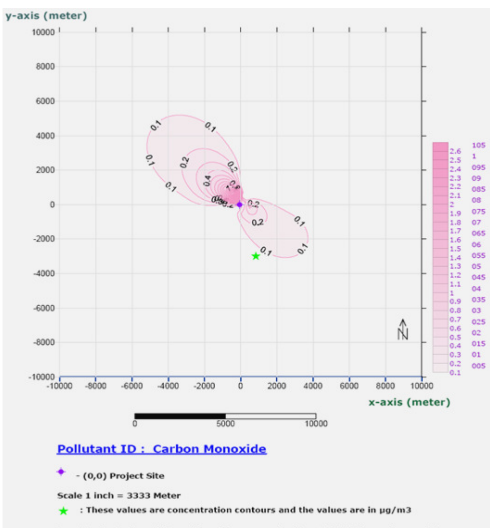

Figure- G

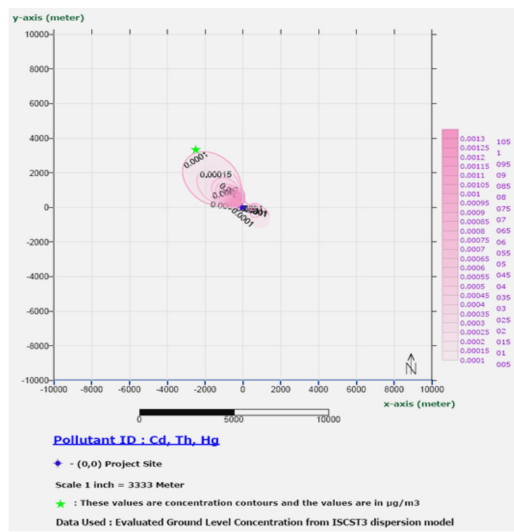

Figure- H

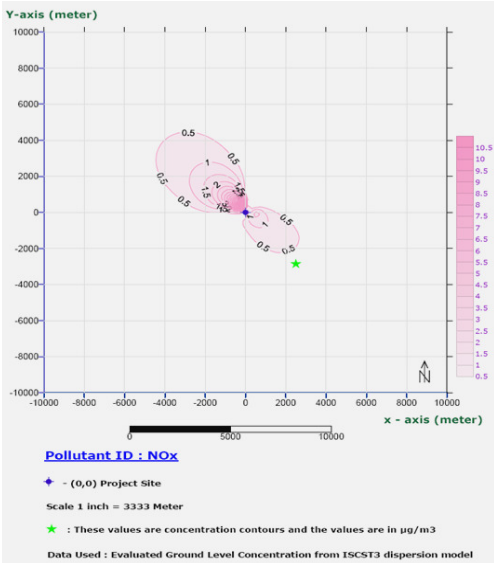

Figure- I

Conclusion and Recommendation

Air quality dispersion modeling not only addresses pollutants directly released in to the environment from a point source (stack), but somehow these pollutants may also responsible for formation secondary pollutants (e.g., acid deposition secondary particulate, PAN, PAB, and ozone, etc). These secondary pollutants forms by reacting with primary pollutants and other substances already present in air environment due to natural or anthropogenic activities.

From the above air quality modeling/contours it can be concluded that the emitting concentration

The ground level concentration (GLCs) values from the above modeling is very less than the stipulated norms subject to condition that the operation of incinerator with a technically/ scientifically sound personnel.

It can be ensured that the consistency in the air quality assessments by adding the above GLCs values and the baseline data of the existing environment vicinity of this incinerator which gives overall ambient air quality (AAQ) of the surrounding area.

It is useful in a decision making with respect to ambient air quality, identification of its likely impact on surrounding area. Also, assist in the determination of stack (chimney) location, stack design, ambient air monitoring network design and selection of alternatives.

References

Air Policy Section Alberta Environment and Sustainable Resource Development, Edmonton, Alberta [2013], Air Quality Model Guideline.

Central Pollution Control Board [1998] Assessment of impact to air Environment Guidelines for conducting Air Quality Modeling.

Bhargava A, Patel P [2011], National Conference on Recent Trends in Engineering & Technology at B.V.M. Engineering College, V.V.Nagar, Gujarat; Air dispersion models for different applications-special reference to thermal power plant.

India Meteorological Department [1951 - 1980], *Book of Climatological Tables of Observatories in India*.

Aldrin M& Haff,IF [2005] Generalized additive Modeling of air pollution, traffic volume and meteorology, *Atmos Environ*, Vol. 39: 2145-2155.

Harrison RM, Yin J, Mark D, Stedman J, Appleby RS, Booker J & Moorcroft S [2001] Studies of coarse particle (2.5-10 µm) component in UK urban atmospheres, *Atmos Environ*, Vol. 35 : 3667-3679.

Attri SD, Singh S, Mukhopadhyay B & Bhatnagar AK [2008] Atlas of hourly Mixing height and assimilation capacity of atmosphere in India, Environment Monitoring & Research Centre India Meteorological Department, New Delhi, Ministry of Earth Science Government of India. *Met. Monograph No. Environment Meteorology- 01/2008*.

The Health Protection Agency [2009] The Impact on Health of Emissions to Air from Municipal Waste Incinerators.