

IMPACT ANALYSIS OF DUST POLLUTION WITHIN KATRAJ

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Abstract- Dust emission has become a major cause of environmental pollution which has many adverse effects on living beings and non-living things. Construction industry revolution and development of Southern Pune has led to an increase in the demand of building materials manifold. The process of quarrying for extraction of building materials is responsible for heavy air pollution. Blasting, handling and transportation of aggregates emits large quantity of dust particles within Katraj region. Dry weather condition and high speed wind spreads the dust which increases the environmental risk. The objective to study the analysis of impact of dust pollution on environment within the Katraj region is to assess the potential risks in quantitative and qualitative manner. The core knowledge of dust concentration, behavior and complex properties of particulate matter helps to formulate the methods and policies to exert control on their emission and distribution.

The natural as well as artificial lakes, the source of ground water in Southern region of Katraj, are subjected to the deposition of heavy suspended particulate matter. Through experimentation, it has been observed that the deposition of such dust matter in the local atmosphere has led to significant changes in the physical, chemical and biological parameters relating to natural resources as it reflects in the alarming deviation of these parameters from standard values. The present study will create awareness and save the environment of Katraj from impending consequences of dust particle emission.

Keywords: Katraj, dust pollution, properties of dust, effects of dust pollution.

I. INTRODUCTION

Pune is a cultural and educational capital of the Maharashtra state and it is situated at the elevation of approximately 560 m above mean sea level, in the Sahyadri Range of Hills near west coast of country. The development of many InfoTech industries around the area calls many people every year for an employment. Day-to-day increase in the population leads to increase in basic needs of an individual like vehicles for transportation, houses for shelter which ultimately causing pollution directly or indirectly by means of vehicles, construction etc. For local transportation to conveyance to various places by public transport which includes bus system under PMT & PCMT are operates 960 buses on 184 routes within and aside of Pune.

PMC has jurisdiction over an area of about 243 sq. km. and mostly some area is hilly region, so due to increase in population, destruction of this nature has been observed in some last decades for fulfilling requirement of public which ultimately causing pollution and thus affecting an environment.

Road surfaces and alongside surfaces receive varying amount of air pollution by the process of atmospheric deposition, sedimentation, impaction and interception.

Particularly due to industries, traffic, mining activities, smelters, and construction are some of the main anthropogenic sources of air pollution. Pollutants like SO₂, H₂S, NO₂, O₃ and other oxidants; oxides of carbon and organic gases and vapors are most responsible for polluting an environment.

Slowly and wide encroachment of the hilly region by the quarrying (mining) and crushing activities of the naturally occurring stones for the construction purposes has been observed.

As the industrialization are at high peak within Pune with existing infrastructure. The infrastructure require to establish new industries, commercial complexes and other infra development require large amount of raw material for construction activity. The major raw material utilize in construction is aggregate which obtain from the quarry work.

The stone crushing industry include in general two main operations:

(1) Mining operations (drilling of stone beds, blasting of stone bed with the help of dynamites, loading of bigger chunks of stones onto trucks and transportation of blasted stones to crusher sites)

(2) Crushing operations (hammering of bigger chunks of stones into smaller pieces, crushing of small pieces by feeding it into crushers, for screening into different sizes whichever is required, conveying by conveyor belts, dumping of stone chips outdoors according to size, removal of dust or solid waste and loading of stone chips onto trucks for transportation). But, there is a lack of environmental governance in both the quarries and the crushers which has resulted in considerable degradation of the environment surrounding the locations; stone crushing industry is established^[1].

The Suspended Particulate Matter (SPM), depending on the size and weight of particles, remain in the air for some length of time. SPM larger than 10 µm settle due to force of gravity on surfaces of plants and soil but the smaller ones remain suspended in air for maximum time, and get dispersed and diffused by the wind, and finally deposited on various surfaces^[1].

Dust is a primary aerosol and it is released directly from the aggregate crushing source. It has a dangerous effect on environment including flora and fauna, for example, changed soil pH and fertility, diminishing visibility of the neighboring areas, demolition of habitat, damage of natural resources like valuable plants and wild lives to spread many diseases etc^[1]. Dust is collection of particles, which if thrown into the air remain there for some time. It is assumed, that these are particles with dimensions below 300 µm. The shape of particles depends on the source of dust emission. Particles of organic origin are shaped differently than the non-organic

ones. A notion of particle as a single object is thus conventional. Size of a particle can be specified in certain intervals:

1. Very coarse particles (Size > 10µm)
2. Coarse particles (Size between 2.5µm & 10µm)
3. Fine particles (Size between 2.5µm & 0.1µm)
4. Very fine particles (Size ≤ 0.1µm)

Dust is not a loose substance, but a biphasic system called aerosol. One of phase is the air (dispersing phase) and the other is the solid (dispersed phase)^[2]. In reviewing the harmfulness of dusts, the respirable fraction is the most harmful one, as it reaches the vesicles. The measurement of respirable fractions is made by cyclone selectors, which separate respirable fractions from the other ones.

Considering all above factors and environmental issues it is now very necessary to find out the solution or remedial measure in order to reduce the pollution caused due to crushing of stones and hence to minimize its affect on health which causing diseases either chronic or acute^[2].

Dust: Dust is a complex mixture of various particles in the atmosphere that come from various sources such as soil, volcanic eruptions, dust lifted by pollution and weather. Dust in homes and other human environments contains human and animal hairs, plant pollen, paper fibers, minerals from outdoor soil, textile fibers, human skin cells and many other materials which may be found in the environment and in the surrounding.

Dust particles are present inside the houses wherever human being lives. The occurrence of dust results in the allergies of asthma in many people. They and their faces and other allergens they produce are main components of house dust. They are too heavy to suspend in the air for long time. The settlement of dust takes around 20 to 120 minutes. Dust particles favor a dark, moist and warm climate. They are found in mattresses, bedding, carpets and furniture. They contain enzymes that are released upon contact with a moist surface, which can have adverse effect on person's health at what time the person inhales. These bacteria can harm cells within the human body.

Control of Dust from Atmosphere: The U. S. Environmental Protection Agency (EPA) took the responsibility of minimizing the dust production and the haphazard it is causing. The most probable dust control violations occur at new construction sites in urban areas. United States Federal law states that the construction sites should get a permission to conduct earth moving and should also adopt those practices which will help to control dust emissions. Control measures can be spraying construction and demolition sites with application of water, and preventing the dustfall.

Some of the issues may include:

1. Improving road safety, visibility and crop productivity in agriculture.
2. Reducing dust related health risks like allergic reactions, asthmatic attacks and pneumonia.
3. Providing cleaner air, cleaner homes and cleaner vehicles and promoting better health.
4. Reducing driver fatigue, maintenance and improving fuel economy.

5. Reducing vehicle maintenance costs by lowering the levels of dust that clog filters.

US federal laws require dust control on sources such as unpaved parking lots and roads. Dust in such places can be reduced by mechanical methods including paving or laying down gravel sprinkling water on the surface, vegetable oils or other dust suppressants.

II. LITERATURE REVIEW

Dulal Chandra Saha and Pratap Kumar Padhy presented a paper on Effects of stone crushing industry on Shorearobusta and Madhuca Indica foliage in Lalpahari forest in Centre for Environmental Studies, Institute of Science, Visva-Bharati University, Santiniketan-731235, and India. In this paper they have studied that forest decline is due to the industrial expansion and the resultant air pollution. Encroachment of the forest land by the crushing activities of the naturally occurring stones since early 1960s is found in the district of Birbhum, West Bengal, India. The main aim of study was to find the effect of stone crushing industry on different parameters of Shorearobusta and Madhuca indica which are two broad-leaved tree species of the forest concerned. Also they measured the dustfall suspended particulate matter (SPM) and gaseous pollutants in air^[1]. It was noted that there was a heavy deposition of dust particles on leaf surfaces. The amount of chlorophyll got decreased along with the total carbohydrate which indicated reduction of photosynthesis. Reduction of protein content was also observed. A considerable correlation was found between foliar parameters and air pollutants present in air in the highly polluted sites of the forest close to the source of pollution.

Along State Highway 7 from Rampurhat to village Dumka, clusters of stone crushing units and sizing units are placed at Baromasia. The associated traffic and stone crushing industry the in the area generate a number of air pollutants which hampers the quality of air, particularly during daytime^[1]. The crushing industry at Lalpahari does two main operations:

- (1) Mining operations.
- (2) Crushing operations

As there is a lack of Environmental Governance in both the mining and the crushers, the degradation of the environment surrounding was observed.

The climatic condition is dry and mild with three different seasons that is summer (March–June), rainy season (July–October) and winter (November–February). The highest temperature was recorded in summer is 41°C and lowest temperature recorded in winter is 6°C. The annual average Rainfall recorded is about 1400 mm to 1450 mm. Maximum relative humidity during rainy season is 89.4% and minimum during winter is 48.5%. The direction of wind flow was generally from southeast in summer, from east in rainy season and from northwest in winter.

The study of following factors was done:

1. Study of Ambient Air Quality
2. Measurement of SPM
3. Measurement of Dustfall
4. Measurement of Gaseous Pollutants

After all the study they got results that how the air becomes suffocative and dusty during daytime when almost all the

crusher units run at a time on the roadside. Crusher dusts make the area looks cloudy. Transparency of the atmosphere is highly lost. The dust suspended in the air was observed 4 – 7 times higher than the prescribed standards in India [1]. According to National Ambient Air Quality Standards (NAAQS) provided by the Central Pollution Control Board (CPCB, 1995), the SPM should not exceed $500 \mu\text{g}/\text{m}^3$ in industrial areas. According to the Environmental Protection Rules, 1986 the SPM value of a unit should be less than $600 \mu\text{g}/\text{m}^3$. It was noted that the SPM was lowest during rainy season and highest in winter [3]. SPM recorded at Lalpahari were 20, 18 and 23 times greater than in control site and within the limits in summer, rainy season and winter respectively. Das and Nandi (2002) recorded post-monsoon and pre-monsoon maximum concentration of SPM in a cluster of crushers were 3204 and $4354 \mu\text{m}/\text{m}^3$ respectively [3]. The research carried out based on ambient air quality monitoring for generating information on the existing level of emissions from uncontrolled or partially controlled stone crushing operations, Patil (2001) found that the SPM in the ambient air at crusher sites varies from 2340 to $24000 \mu\text{g}/\text{m}^3$ which are higher than the desirable values [3].

The dustfall in glass jar was found to be lower in winter than in summer at Lalpahari. Dust deposition was maximum in summer and minimum in rainy season. About 14 times higher dustfall observed on Madhuca indica leaf surface [3]. The difference in foliar dustfall in between the two forests was noted. A thick coat of dust was always found on leaf surface. Thus it can be concluded that Mohul leaf received more dust than Sal, which was found in the experimentation in winter and rainy season.

III. METHODOLOGY

The potential health hazards caused by inhalation of airborne dust closely relate to the particle size, dust concentration and constituents of the dust. The purpose of this study is to identify the potential health risk to the residents of southern Katraj from the dust. During the assessment of this study, it is necessary to have clarity about the size of dust particles, amount of exposure and the toxic nature of dust particle. The aggregate crushing, stocking, loading and transporting facility is virtually adjacent to the Yewalewadi Township. The aggregate industries stockpile large amount of dust particles in open environment, which impacts southern Katraj region. The exacerbation of dust emissions in Southern Katraj has become easy due to dry and windy climate.

The potential risk to the environment in southern Katraj region from the dust to which the population is experiencing becomes an important issue to be address due to awareness of people. The limited knowledge of the adverse health effects of dust mass concentrations, dust composition and its toxicity is also responsible for the same. Reliable measurement and control of dust exposure at southern Katraj become a base recommendation, which can help to compare the local environmental data with previously analyzed air quality standard at possible basis to know the acceptable level of dust exposure at southern Katraj region.

Daily fluctuation in dust mass concentration of ambient air pollution is mostly responsible for the adverse environmental impact. US EPA has recently found some

evidence to implicate PM_{10} to $\text{PM}_{2.5}$ in adverse health effect. EPA recommended mass of PM_{10} to $\text{PM}_{2.5}$ in air quality standard is $70 \mu\text{g}/\text{m}^3$ for a period of 24 hours [4]. It is difficult to conclude the air quality standard of southern Katraj region irrespective of informative data. Collection of reliable and valid air quality data is an important step towards problem resolution.

A. Materials and Methods

Description of the Study Area and Selection of Study Stations: The selected area, Southern part of Katraj area Pune is situated at $18^\circ 27' 13''\text{N}$ $73^\circ 51' 42''\text{E}$ which is covered by hilly ranges. The Southern Katraj covers Khadi Machine Chouk, Bopdev Ghat, South Yewalewadi and North Yewalewadi. For the analysis and determination of dust, selection of four different study stations is as follows:

1. Khadi Machines Chouk, under Katraj-Kondwa Range, is connecting roads toward Katraj, Kondwa, Yewalewadi and Solapur Road which shows heavy traffic loads. ("Station 1")

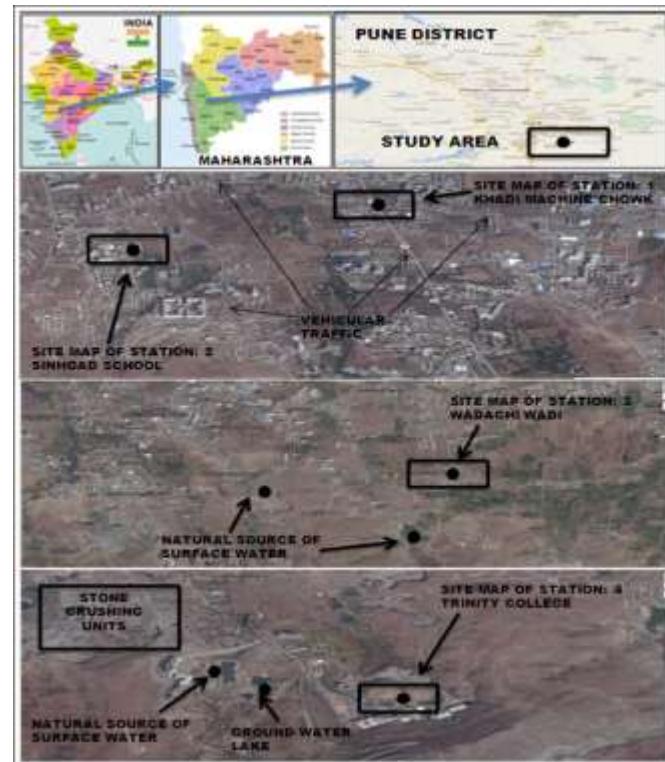


Fig. 1: Map Representing Study Areas

North Yewalewadi, is an ideal home for a large number of aggregate industries covers an area of 3 Km^2 which is heavily polluted as crushing of naturally occurring rocks take place in entire area. As for instance, over 21 crusher units are found in area of only 3 Km^2 at Yewalewadi. ("Station 2")

2. South Yewalewadi is also affected by large number of aggregate industries and aggregate crushing plants. ("Station 3")
3. Trinity College of Engineering campus which is located at 3 Km next to Yewalewadi in Bopdev Ghat. It's a developed area of around 108 Acres, which is continuously under the influence of crushing units. ("Station 4")

"Station 1" situated along the Katraj-Kondwa road which known as heavy traffic junction, "Station 2" situated farther 700 m north from Sihgad School which open area for aggregates transporting Dumpers, Tracks , JCBs and Tractors, "Station 3" farther 1000 m South from Yewalewadi and "Station 4" basically known as Bopdev Ghat, for studying some parameters.

Monitoring, determination, analysis and study of the dust concentration and its effects are under execution for selected for different site. "Station 4" which selected at Bopdev Ghat surrounded by developing construction sites (about 15 to 25 meters away from the crushing units concerned, i.e., at an average distance of 20 meters from the crusher units) is exposure to heavy dust pollution. So among the above discussed stations: (i) station 1-moderately polluted, (ii) station 2- highly polluted and (iii) station 3- highly polluted. As the dust matter show complex nature, there are several methods to determine the concentration of dust.

B. Overview of local geology

Katraj is suburb of Pune in Maharashtra state of India, which lies between Dhankawadi, Balji Nagar, Kondwa and Khed- Shivapur and within the jurisdiction of Pune Municipal Corporation. The hill ranges commonly known as Katraj Ghat, which is a mountain pass lies on the Mumbai - Chennai National Highway. It is the southernmost area of Pune city. The southern Katraj region consists of mixed Land Besalt and Granite rocks and the soil is made by depreciation of rocks. Black soil, Purple Soil, Rock soil, Calcium soil & Potassium soil are the types of soils found in local area [5]. Due to the less widespread plant life, the atmosphere contain low levels of oxygen this results in the development of iron and manganese ores at the earth's surface which are very distinct in mineralogy and texture from those formed in later geological history.

C. Local climatic conditions

The climate is dry with three distinct seasons such as rainy season (July–October), winter (November–February) and summer (March–June).

The minimum humidity recorded during winter is 48.5% and maximum during rainy season is 89.4% [6].

Generally Monsoon starts in June. Monsoon comes from South-west. In the western part of Pune district the annual average ratio of rainfall is up to 400 cm. In Maval area rainfall is 200 to 400 cm. The average rainfall is 50-100 cm in Western side of Pune District which covers Bhor, Velha, Maval, Mulashi, Khed, Ambegaon and Junnar Talukas. The average rainfall is 1171 mm is in Junnar. From West to East rainfall ratio is less. For the East Tarkas minimum average of rainfall is less than the average [6].

D. Local Ambient Air Quality

As per data obtained from sources the studies have been undertaken in six major cities of India, viz. Bangalore, Delhi, Pune, Kanpur, Chennai and Mumbai. The most critical is to focus on apportionment of respirable PM₁₀ and PM_{2.5} matter. The purpose of studying this local ambient air quality is to know the baseline data of ambient concentration of air

pollutants and sources of their emission. A detail air quality monitoring practices were carried out for a duration of 12 months at different locations such as two kerbside sites, two residential sites, one industrial site, one background site and one institutional site.

E. Dust Monitoring Methods

In the beginning, EPA was working to get total concentrations of total suspended particulate matter, now recently it approach toward monitoring and regulating total suspended matter in ambient air. Nowadays researchers have great interest to detect smaller particles like PM_{2.5} & other types & behaviour of various organic & inorganic substituent of total suspended matter.

Filtration, thermal & electrical precipitation and inertial separators are the available sampling devices and techniques employed to detect suspended particulate matter from ambient air.

F. Measurement of dustfall

The study area is always under the influence of 21 crusher units which emits large amount of dust in to surrounding atmosphere. The amounts of dustfall at different places were measured with the help of glass jar kept at different elevations. The glass jars were cleaned and pre-weighed (a) before it placing at location which was under test. The initial time of glass jar placing is recorded. The weight of dustfall along with glass jars (b) recorded at the end of test duration. Then the glass jars were cleaned and weighted again for a next test. The weight of dust deposited in the glass jar in one day was calculated. The glass jar mouth area is measured and the dust deposited was expressed as g / m² day. The total dustfall was calculated as g / m² day by using following formula

$$\text{PM Dust fall } \left(\frac{\text{g}}{\text{m}^2 \text{ day}} \right) = \frac{\text{PM mass (g)} \times 1}{\pi r^2 \times n}$$

Where (πr^2) is the cross sectional area of the jar mouth in m², 1 is one day duration of dustfall testing, n is the actual duration in hours for which glass jar was exposed [1].

IV. RESULTS AND DISCUSSION

A. Measurement of dustfall

The deposition of dustfall in glass jars was found to be unpredictable with respect to place to place within the study area at 12 to 15 m height from ground level. The amount of dustfall in glass jars during summer was found to be higher than in winter. As the temperature went increasing day by day, the layer of tiny dust particles were found over South Katraj area.

The least value of dustfall was observed at station 4 sample ID 2 as wind flows from station 4 sample ID 2 to the crushing units. Results are shown in Fig. 2.

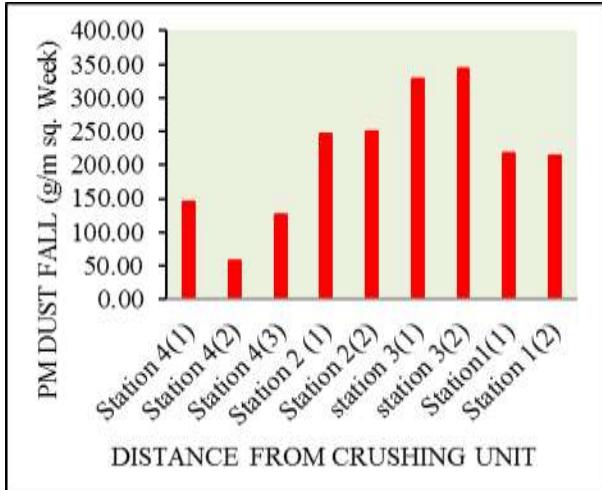


Fig2. PM dust fall (g/m sq. Week) vs distance from crushing unit

The highest dustfall was recorded at Station 3 sample ID 2 as it is under the influence of two crushing zones one of which is in the North- West of Trinity College and the other is in the South East of Trinity College which leads to significantly perceptible increment in the dustfall obtained from the samples of the area.

The Station 2 and 1 showed higher dust fall followed to Station 3. These two stations recorded higher dustfall as these are situated in direction of wind flow.

B. Effect of dust pollution on water bodies

As the distance of sources of ground water and surface water increased from cluster of crusher units, the properties of water also have shown large deviations in their readings. The pH of ground water slightly decreased as the distance on source increased from the stone crushing zone.

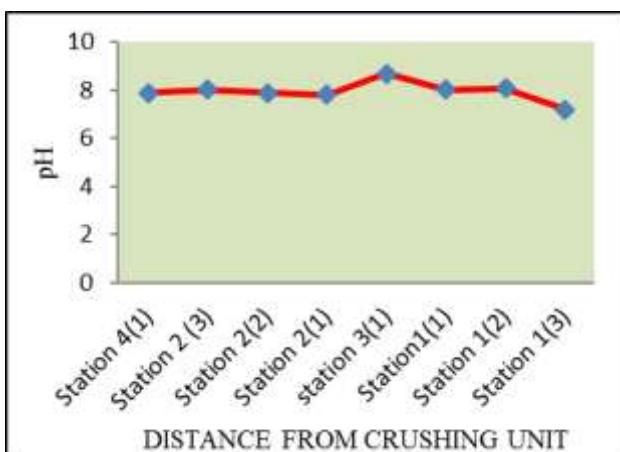


Fig3. pH vs distance from crushing unit

The pH of surface water has shown large variations as the distance on source increased from the stone crushing zone. It is shown in following graph.

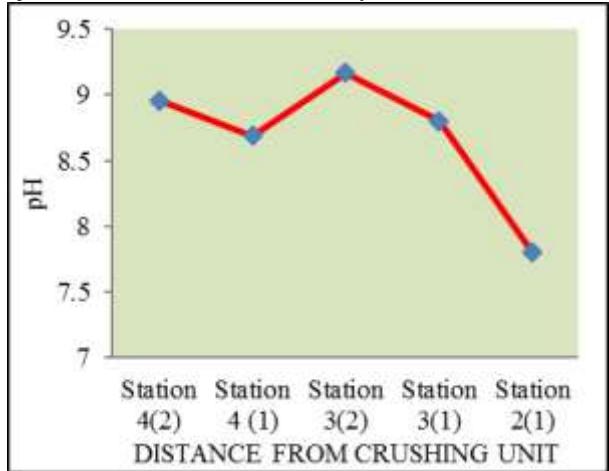


Fig4. pH vs distance from crushing unit

Turbidity of ground water is shown in following graph which shows significant deviation as the distance increases from crushing unit. Station 3 is under the influence of two crushing zones one of which is in the South of Trinity College and the other is in the North of Trinity College which leads to significantly perceptible increment in the turbidity obtained from the samples of the area.

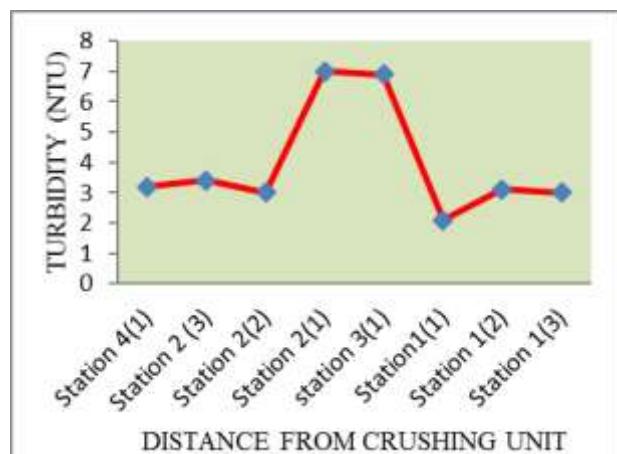


Fig5. Turbidity vs distance from crushing unit

Turbidity of surface water is deviated in a large scale as shown in following graph.

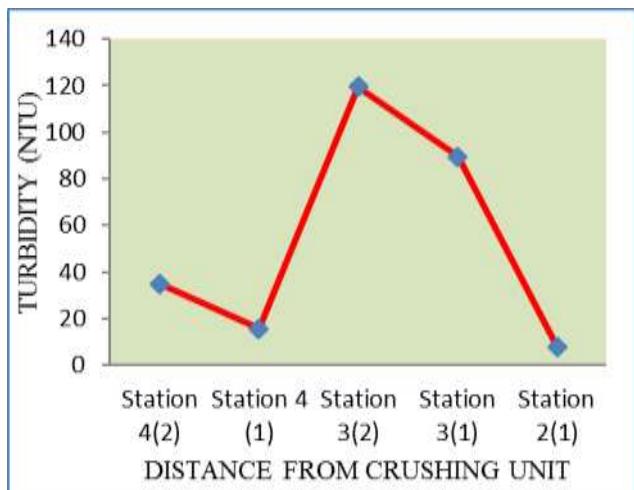


Fig6. Turbidity vs distance from crushing unit

The electrical conductivity of ground water reduced as the distance of sources of ground water increased from crushing unit which is shown in figure below.

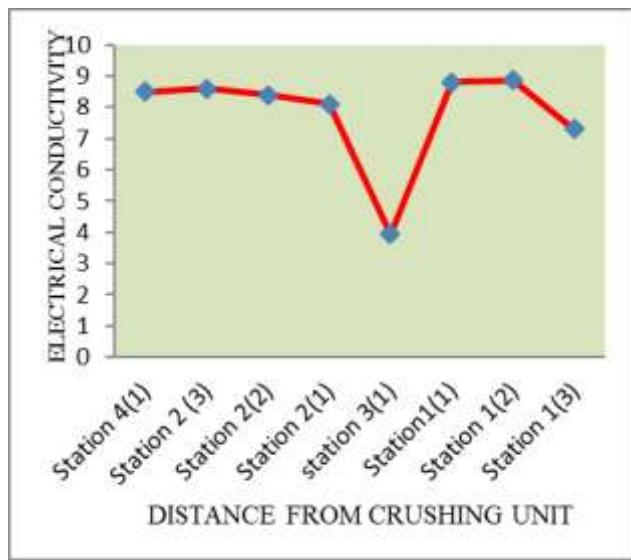


Fig7. Electrical conductivity vs distance from crushing unit

The electrical conductivity of surface water was badly affected. The electrical conductivity had distinctly low reading as the distance of sources of ground water increased from crushing unit which is reflected in Fig 8.

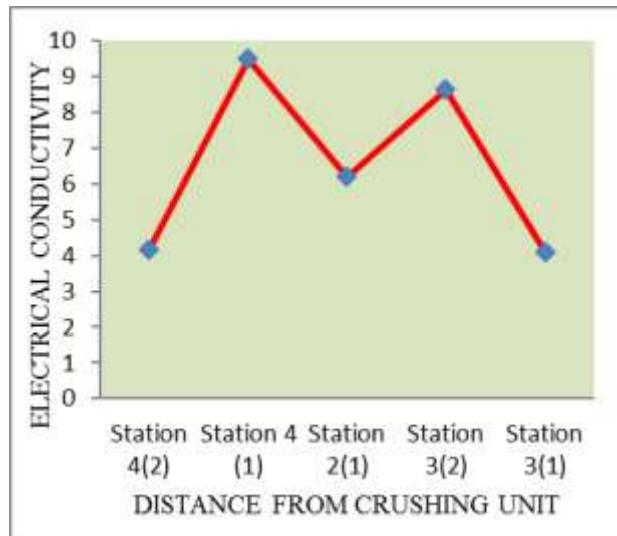


Fig8. Electrical conductivity vs distance from crushing unit

Total Alkalinity of groundwater sources increases for station 2 and fall is again observed for Station 3.

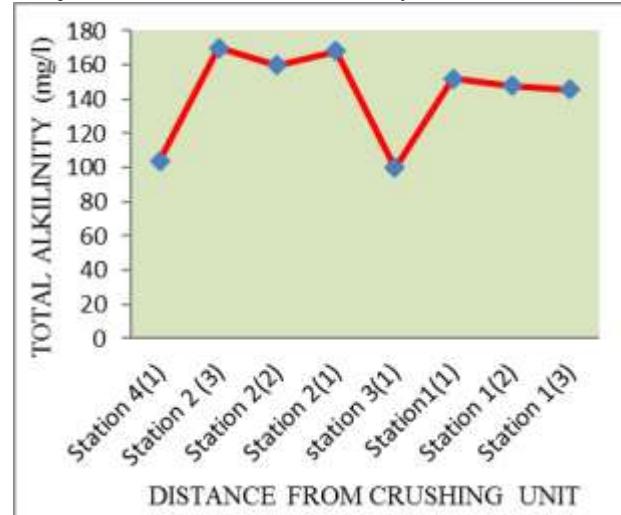


Fig9. Total alkalinity vs distance from crushing unit

Total Alkalinity of surface water sources decreases suddenly for station 4, sample ID 1 as the water is collected from a source originating in water percolation. the alkalinity again increases for station 3 as it is affected by two adjoining crushing zones.

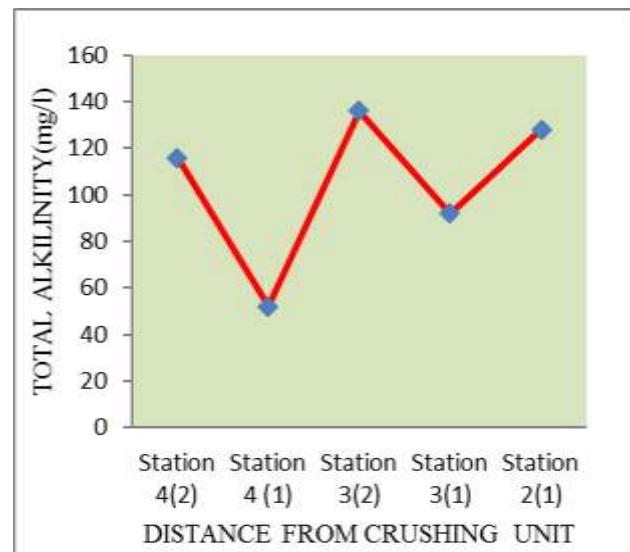


Fig10. Total alkalinity vs distance from crushing unit

The total hardness of groundwater slightly decreases as distance of ground water source increases from crushing unit up to station 3, Sample ID 2 and it rapidly increases for station 3 Sample ID 1. The total hardness obtained for station 2 sample ID 1 is very low as it is located very far from the crushing unit in Katraj.

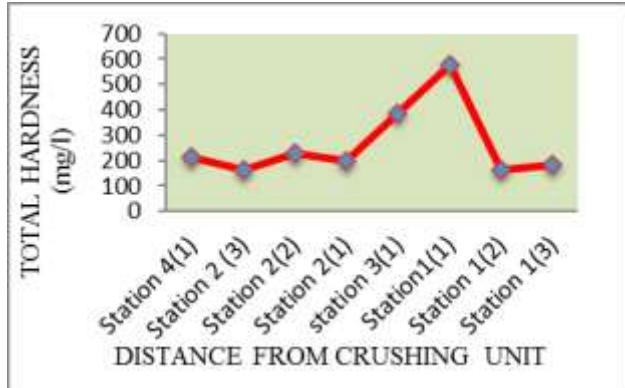


Fig11. Total hardness vs distance from crushing unit

The total hardness of sources of surface water decreases for station 4 Sample ID 1 and then gradually increases till station 3 Sample ID 1 and then falls again for station 2 as shown in figure 12.

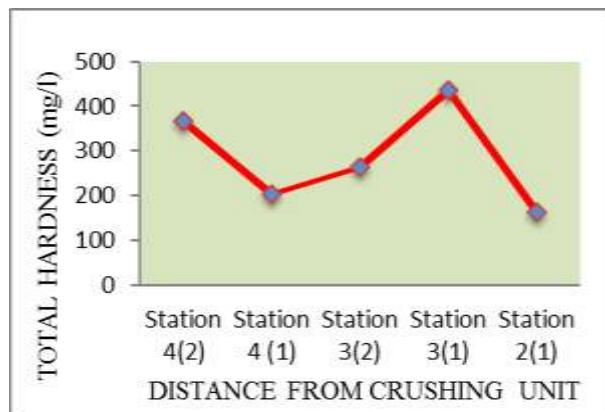


Fig12. Total hardness vs distance from crushing unit

C. Effect of dust pollution on vegetation

The dustfall on plant leaves is shown in figure 13 which directly affects the photosynthesis in leaves. This causes damage to the plant health as well dust accumulation on leaves causes' damage to plant tissues [1].

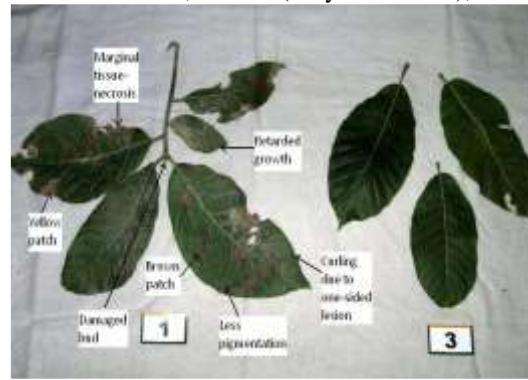


Fig.13: Foliar injury symptoms of freshly collected leaves
 (source: Dusal Chandra Saha, Pratap Kumar Padhy)

V. CONCLUSION

The associated processes of aggregate manufacturing like mining work, aggregate blasting, cutting, hauling, processing and transport of aggregate are the main cause of dust pollution in Southern Katraj region. The dry climate, lack of plantation and strong winds, favor the formation of dust as observed during recent years. The aggregate production rate is also high which adds large amount of dust matter in open environment. It causes air pollution, water hardness which directly affects respiratory system and the diseases related to the same. The villages located in wind corridors are severely exposed to dust storms and have to face the problems related to respiratory system as well as lack of visibility while driving. The dust deposition on open land transforms the cultivable land into wasteland thus rendering it unsuitable for agriculture. All these factors and affects call for preventive measures.

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