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CONTENTS

Herbicidal Pollution—Low Production and Chlorophyll Damage Due to Herbicide Vapours

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Ester formulation of 2,4-D was sprayed at the rate of 1.00 and 1.5 kg ha^{-1} in a field of brinjals. A significant reduction in production and chlorophyll content in the leaves of treated fields was noted and reported for the first time in the country. No significant difference in respiration was observed. The study cautions about the extravagant use of these chemicals.

INTRODUCTION

Herbicides, because of their specific killing actions, are widely used and without consideration of the post-application effects. It has already been pointed out that herbicide vapours can damage the nontarget plants also, (Zimmermann[1], Mullison and Hummer[2], Day *et al*[3], Ketchersid *et al*[4], Dubey and Mall[5], Dubey[6]). The present study deals with the effect of the herbicide vapours on the productivity of the brinjals and its chlorophyll content.

EXPERIMENTAL MATERIAL AND METHOD

Ester formation of 2,4-D (2,4-Dichloro phenoxyacetic acid) was sprayed at the rate of 1.00 and 1.5 kg ha $^{-1}$ in a field infested with weeds associated with brinjal (*Solanum melanogena* Willd). Leaves samples were collected from treated and untreated fields for analysis. These samples were experimentally analysed on the same day. Productivity measurements were done by PRLD method described by Bartos *et al.*[7] while chlorophyll contents were estimated by colorimetric method, suggested by Arnon[8].

RESULT AND DISCUSSION

The results presented in Table 1 show that the gross production is certainly affected because leaves of the plants from treated and untreated plots have a significant difference in values of GP when tested by T-test. The GP is reduced by 0.98 and 2.32g^{-2}h^{-1} in the plots sprayed with the rate of 1.00 and 1.5kg ha^{-1} of 2,4-D respectively. In fact 1.00 kg ha^{-1} is a dose which can not offer a control of the LD_{50} level, hence, higher doses are given. Evidently all such fields will have a post spray period of low dry matter production. The data of respiration, where breakdown of photosynthate is taking place, are statistically insignificant (T-test) indicating that this process is not seriously affected. Table-2 shows the measurements of chlorophyll contents from controlled and treated fields. There was a continuous reduction in chlorophyll content after 2nd, 4th and 6th day of treatment. This was due to the fact that the photosynthetic apparatus is damaged by the herbicidal vapours and the damage can be correlated with the low production. In general it was reported that compounds of this family mostly affect the nucleotide responses and enzymatic systems. Woodford *et al*[9]. Penner and Ashton [10], Ashton and Crafts[11]). Wort[12] indicated that 2,4-D can affect the pigments including chlorophylls. The present work further supports that 2, 4-D can also reduce the green pigment content of the crop plants like brinjal. It may be inferred that herbicides and particularly volatile formulations may prove deletarious in the production of dry matter and become serious pollutants of the air.

Table 1—*Dry matter production in leaves of brinjal sampled from treated and untreated fields.*

Leaf samples	Initial Dry wt. gm^{-2}	NP $gm^{-2}h^{-1}$	R $gm^{-2}h^{-1}$	GP $gm^{-2}h^{-1}$
Untreated	20.1±1.02	1.80±0.4	2.92±0.48	4.72
Treated (1 kg ha^{-1})	19.96±1.6	1.34±0.6	2.4±0.52	3.74*
Treated (1.5 kg ha^{-1})	19.90±1.3	0.42±0.11	1.98±0.39	2.40**

NP=Net Production; R=Respiration; GP=Gross Production; T=Significant at .01 and .001 levels with untreated controls.

Table 2—*Chlorophyll content (mg/g) in leaves of brinjal*

Before treatment	After Treatment (1.5 kg h^{-1})		
	2 days	4 days	6 days
4.12	4.01	3.79	3.26

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Response of Two Crop Varieties to Sulphur Dioxide

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Chlorophylls are the most important plant component which trap solar energy and utilize it in photosynthetic process. Sulphur dioxide is a universal pollutant. Seedlings of wheat and gram when subjected to 0.5, 1.0 and 3.0 ppm of SO_2 expressed no visible injury symptoms but a correlation was obtained between chlorophyll damage and SO_2 concentration.

INTRODUCTION

Sulphur dioxide is one of the most common and oldest known primary pollutant from power generation and space heating industries.[1] It is a recognized agent causing significant damage to natural vegetation. Pollutants enter in leaf through stomata with other gases, induces alterations in various biochemical and physiological process including degradation of photosynthetic pigments.

Damaging effects on plants were studied by many workers i.e. on Lichens[2], on Bryophytes[3,4], on higher plants[5,6,7]. The wheat and gram are the common crops of the area and hence effects of SO_2 on the Narmada 4 variety of wheat and No. 355 variety of gram have been studied.

EXPERIMENTAL METHODS

Germinated wheat *(Triticum vulgare L. var. Narmada 4)* and Gram *(Cicer arietinum L. var. 355)* seeds were exposed to SO_2 doses in 0.5 m^3 size closed transparent polythene chamber under laboratory conditions. Plants were potted in petri dish (10 cm) containing 100 gram black cotton soil. A set of three petridishs each with 10 seeds was placed in each chamber. Control sets were also placed in a similar chamber without SO_2. The measured concentration of sulphur dioxide, 0.5, 1.0 and 3.0 ppmday^{-1} was given from 08.00 A.M. to 12.00 A.M. daily for a period of 8 days.

Desired SO_2 concentrations in chamber were obtained by reacting Na_2SO_3 with dilute H_2SO_4 by the relationship that 2.6 mg of Na_2SO_3 with dilute H_2SO_4 releases 1 ppm SO_2 in 1 M^3 air[2]. The released SO_2 get mixed with air in the chamber produces the desired SO_2 concentration.

Chlorophyll content of plant samples was deter-

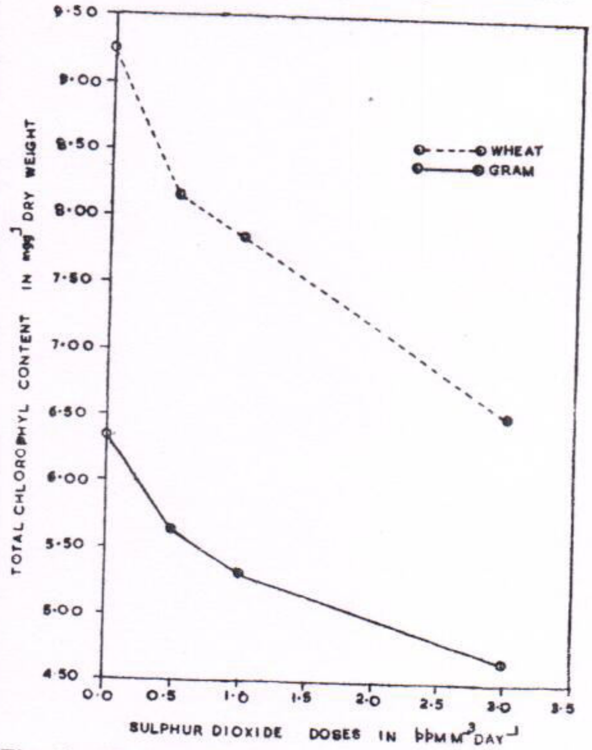

Fig. 1 *Effect of SO_2 doses on total chlorophyll content of crop plants.*

mined following Arnon method[8]. Root and shoot length of 8 days old plant were noted.

RESULTS AND DISCUSSION

During the experimentation no symptoms of visible injury, necrotic or chlorotic patches were noted even at the 3.00 ppm doses of SO_2 in all the plants but all plants showed unspecific chlorosis as compared to controls. The chlorotic action of SO_2 is further confirmed statistically because of chlorophyll content of SO_2 exposed leaves was in correlation ($r = -1.000$ of wheat and $r = -0.9169$ for gram) with the increase in SO_2 doses. Quantitative determination reveal that chlorophyll content was reduced by 4.67, 8.29 and 22.19 percent in wheat and 5.89, 7.57 and 19.02 percent in gram with the respective doses of SO_2 (Table 1). However, plant growth was not seriously affected within the experimental period i.e. 8 days, as insignificant change in root and shoot length of exposed and unexposed plants were noted (Table 2).

Table 1—*SO_2 Doses and Chlorophyll Content of Treated Crop Plants*

SO_2 concentration (ppm)	Cumulative SO_2 dose (con. × hr × days)	WHEAT var. N 4			GRAM var. 355		
		Chl.a	Chl.b	% decrease in total chl.(a+b)	Chl.a	Chl.b	% decrease in total chl.(a+b)
Control	—	5.56	3.70	—	3.92	2.44	—
0.5	$0.5 \times 4 \times 8 = 16$	5.11	3.05	11.87	3.49	2.13	11.63
1.0	$1 \times 4 \times 8 = 32$	5.06	2.79	15.22	3.25	2.04	16.82
3.0	$3 \times 4 \times 8 = 96$	4.12	2.543	28.18	3.05	1.66	26.88

Table 2—*Root-shoot length (cm) of SO_2 Treated crop Plants**

	Control		0.5 ppm (14 ppm)		1.0 ppm (28 ppm)		3.0 ppm (84 ppm)	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
Wheat	19.16 ± 2.44	28.43 ± 0.60	19.73 ± 3.19	28.73 ± 2.19	17.43 ± 2.63	27.16 ± 1.67	17.43 ± 1.77	27.05 ± 0.60
Gram	24.15 ± 0.88	24.41 ± 0.04	25.15 ± 1.06	25.76 ± 0.59	23.48 ± 1.58	24.96 ± 0.74	22.71 ± 2.22	24.81 ± 1.44

* average of 30 seedlings

The degradation and consequent decrease in the levels of chlorophyll in fumigated plant may be due to the acid hydrolysis in which chloropyll a is broken and a sulphite is formed within tissue which is then transformed to sulphate and the latter is about 30 times less toxic than sulphite[3]. The lack of marked visible symptoms can be explained in this light that obviously in the present study, also, because of intermitant pollution due to SO_2 this mechanism was operative. This supports Pandey and Rao[7] who also could not find any folior injury symptom even at a very high cumulative doses of SO_2.

Acute injury occurs only when more of the pollutant is taken per unit time at high concentration so that less time is available for detoxification of the pollutant in the plant[9,10]. However it was reported that comparatively chlorophyll a is more sensitive to SO_2 than chlorophyll b but the present work support the recent information that both a & b are affected and are quite sensitive[7]. The insignificant change in root and shoot length may be due to the fact that Gram crop plants are most resistant during early stage and a longer exposure to more older plants may induce the effects.

ACKNOWLEDGEMENT

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Monitoring the Dust Concentrations in Various Seed Cleaning Plants in Manitoba

Daya Nand* and L.C. Buchanan.**

Dust control in farm seed cleaning plants is of paramount importance as harmful effects of grain dust are well known. Dust emission levels in relevent seed cleaning plants were measured and several particle size analyses were conducted in order to study the grain dust properties. Approximately 40% of the farm seed cleaning plants that were surveyed in this dust monitoring study had dust levels larger than the acceptable limit of 10 mg/m³.

INTRODUCTION

The concentration of dust in the seed cleaning plant environment will vary depending on the type of operation, field source of grains, type of seed, harvesting methods, weed present and chemical residual. The level of emission will also depend upon the type and design of the cleaning and grading machines. These machines may be open to the atmosphere or of closed type having a cross-current or counter-current type of air flow. The finer the dust the more severe the atmospheric pollution problem would be because fine particles remain in suspension for a longer period of time.

The effect of grain dust on workers exposed to grain dust contaminated conditions is still controversial and is related to a number of contributing factors such as individual resistance and smoking habits. Many individuals experience bronchial or allergic disturbances after exposure to feed and grain processing dust. Grain dust exposure produces discomfort or temporary physiological alteration due to dust accumulation in the bronchial tract prior to the development of chronical disorders. According to Labour Canada, the effects of grain dust on health is a complicated one.

Extensive property damage and fatal accidents in grains elevator explosions are well known. The major cause of a grain dust explosion is the accumulation of fine, dry dust on processing equipment and pipe which may be ignited by any heat source such as a flame or spark. In grain handling industry it is important to prevent any dust accumulation so as to avoid these explosions.

Labour Canada and Health and Welfare Canada have adopted a provisional standard which provides an employee exposure to a maximum of 10 mg. of total grain dust per m³ of air averaged over any eight hour daily period and a 40-hour work week[1]. Grain dust is of complex nature and its charactertistics affect the collection efficiency. A need now exists to know the present level of dust emission in grain handling systems on the farm.

REVIEW OF LITERATURE

Dust is the most important problem of the working environment in farm seed cleaning plants. Unfortunately, no specific information is available on the dust emissions in the environment of the farm seed cleaning plants. However, many researchers measured dust emissions from various operations during grain handling in the grain elevators. It was found that a considerable amount of dust is generated during unloading of grains from trucks at the receiving hopper at grain elevators. According to Thimsen and Aften[2], the amount of dust generated while unloading at the receiving hopper

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was 0.10% of the grain mass. In Saskatchewan, Yoshida and Maybank[3] found that at the receiving hopper, the dust concentration varied from 20-40 mg/m^3 of air handled.

The mass concentration level of dust in the working environment depends on the type of grain handled. Yoshida and Maybank[3], in one of their studies on grain dust emission in elevators, found dust concentrations of 892 mg/m^3 and 81.9 mg/m^3 of air handled from the spout pent house for barley and wheat respectively. Getchell *et.al*[4], while conducting tests on the use of additives for grain dust reduction during handling observed dust concentrations as high as 2558 mg/m^3 in handling combine harvested wheat.

Dust is generated during the grain handling process. The main sources of dust generation in seed cleaning plants are grain receiving hoppers, transfer points such as bucket elevators, belt conveyors, screw conveyors, loading and unloading of bins and cleaning and grading machines. Thimsen and Aften[2], William[5], Martin and Sauer[6], Norman et. al[7], Yoshida and Maybank[8], discussed various sources of dust generation in the grain industry especially in grain elevators.

Two commonly used methods that are employed for determining the total dust concentrations in the working environment are the sampling jars and high volume air sampler. High volume air sampler is a more accurate and quicker method for sampling dusts. Annis[9], Morrow *et.al*[10], Martin, and Sauer[6], Avant *et.al*[11], Kirk *et.al*[12], Norman *et.al*[7] and Parnell *et.al*[13] used the high volume air sampler for determining total mass concentrations of grain dusts in the working environment. For particle size analysis, Andersen sampler is used.

Regardless of the sampling system used, it is essential to have isokinetic sampling for accurate determination of dust loadings. This means maintaining inlet velocity equal to the duct velocity at the sampler inlet point.[9,10,4]

METHODS AND MATERIALS

Dust emission levels were measured in 11 farm seed cleaning plants situated near Winnipeg, Manitoba in order to assess the pollution problems in the working environments. A High Volume air sampler was used to monitor total dust emission in the plant's environment. The sampler was calibrated in the laboratory according to the instruction manual. A calibration curve (Figure-1) was drawn to correct the observed air flow rates as shown in Figure-1. Fibreglass filters were conditions for 24

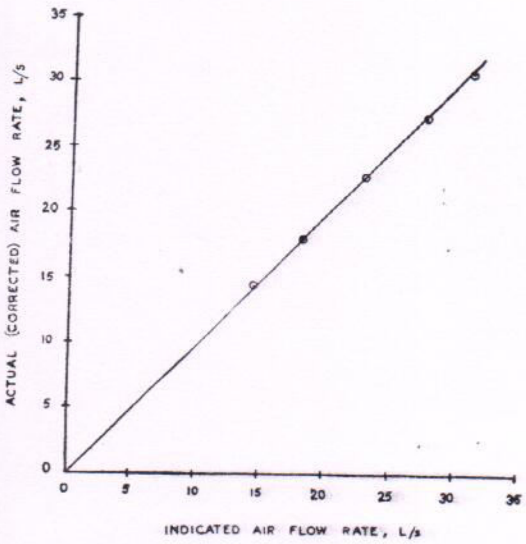

Fig. 1. *Calibration of High Volume Air Sampler*

hours in a desiccator prior to use. The tare mass of the filter was obtained with a balance scale and recorded along with filter identification number. These filters were then used at the plants for collecting dust samples. For sampling, the High Volume sampler was located near the largest emission source in the working environment. The filter was installed in the filter holder and the sampler was operated for one hour. Rotameter readings were taken at the begining and at the end of the test, to measure the average air flow rate through the filter paper. Temperature of the ambient air was also recorded. The filters were carefully put in the manilla envelopes and transported back to the laboratory and allowed to equilibrate for 24 hours in the desiccator prior to the weighing. Figure-2 shows the exposed filter. The filter mass minus weight differences before and

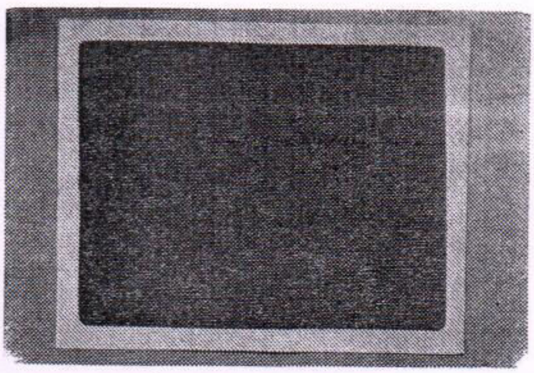

Fig. 2. *Exposed Fibreglass Filter*

after sampling will give us total mass of the dust sample. The total volume of air that passed through the filter was calculated from the average air flow rate and sampling time. The total dust mass divided by the total volume of air that passed through the filter yielded the dust concetration in mg/m^3.

For particle size analysis the Andersen head (Figure-3) was used on the high volume air sampler as shown in Figure-3. Preconditioned and pre-weighed filters were installed in the Andersen Particle sizing head. The sampler was put near the emission source in the plant environment and the Andersen head was fitted on the sampler. The sampler unit was started and the air flow rate through the filters was adjusted to 9.44 l/sec with the help of a variable output transformer. The unit was allowed to operate for about two hours. The sizing head was then removed from the sampler and transported to the laboratory, where the filters from each stage were removed carefully and put in the desiccator for conditioning for 24 hours. The filters were weighed again and the mass of the dust on each stage was determined from the gross mass minus tare mass of each filter. The total mass divided by the volume of the air drawn through the filter, yielded the dust concentration in mg/m^3 of air on each of five stages of the sizing head.

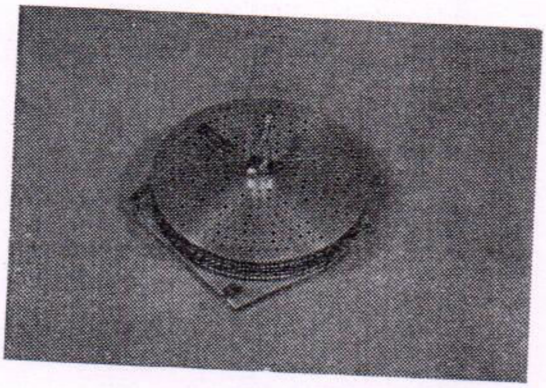

Fig. 3. *Andersen particle sizing head*

Using the net dust mass on each stage, the cumulative percentage were calculated for each stage. A linear regression representing the particle size distribution with percent cumulative mass as the independent variable and the natural log of particle diameter as the dependent variable was determined for each sample. The mass median diameter and goemetric standard deviation were calculated to describe the particle size distribution pattern.

RESULTS AND DISCUSSIONS

Dust emissions from various farm seed cleaning plants is presented in Table 1. It was observed that four out of eleven seed cleaning plants surveyed do not meet the allowable threshold limit value ($10 mg/m^3$) of dust emission in the grain industry set by Environment Canada[1]. The remainder of the plants are within the allowable limits and there seems to be no danger of pollution in the near future with the exception of plant 9. As it was very near to the allowable limits of dust emission and the existing dust control system in the plant will need improvements in order to lower the dust emission level in the working environment. Total dust emission was lowest in plant-7 being 1.04 mg/m^3 of air handled whereas a maximum of 114.23 mg/m^3 was observed in plant-10.

The dust emission level in a seed cleaning plant depends on the type of crop seed cleaned and the sampling location. In plant-4 more dust was generated in the working environment while cleaning barley than wheat. The dust concentration near the dump hopper was 114.23 mg/m^3 in plant 10, during the cleaning operation in the same plant, the respirable dust level was 6.99 mg/m^3. This value was much higher than that reported by Yoshida[3] for the receiving hoppers in grain elevators. They reported a mass concentration of 40 mg/m^3 of air handled for wheat and barley.

The respirable mass fraction of grain dust was determined in three plants (4,8 and 10) only by the Andersen head. Wheat generated more fine dust than fababeans and peas but the respirable mass fraction in fababeans and peas was almost equal. These levels are very close to total allowable limits and may pose serious health hazards as respirable dust penetrates to the lungs.

Figures 4 and 5 represent particle size mass distribution curves for wheat, fababeans and peas in the three plants. The particle size distribution function follows a long-normal distribution except wheat dust. The mass median diameter and geometric standard deviation values in wheat dust were 78.75 μm and 20 μm respectively. The probable reason for these large values may be due to (i) a large percentage of dust particles emitted in plant were greater than 7 μm, and (ii) The physical charactertistcs of wheat dust and the heavy conentration of particles could have resulted in larger particles forcing the small size particles. Out of the jet stream thus impacting on the filter surface. Due to these factors a high percentage of dust was collected on the first stage. Matlock and Parnell

Table 1. *Dust emissions from various farm seed cleaning plants.*

Date sampled	Site code or plant number	Crop seed	Dust concentration mg/m³	
			Total	Respirable
27.4.78	1	Wheat	7.46	—
9.5.78	1	Wheat	20.65	—
28.4.78	2	Wheat	2.78	—
1.5.78	3	Wheat	1.07	—
2.5.78	4	Barley	60.44	—
27.4.79	4	Wheat	55.06	47.0
4.5.78	5	Wheat	2.64	—
4.5.78	6	Barley	3.40	—
15.5.78	7	Flax	1.04	—
19.4.79	8	Fababeans	—	7.39
4.5.79	9	Oats	7.7	—
22.5.79	10 (Dumping)	Peas	114.23	—
22.5.79	10 (near cleaner)	Peas	—	6.99
22.5.79	11	Barley	37.17	—

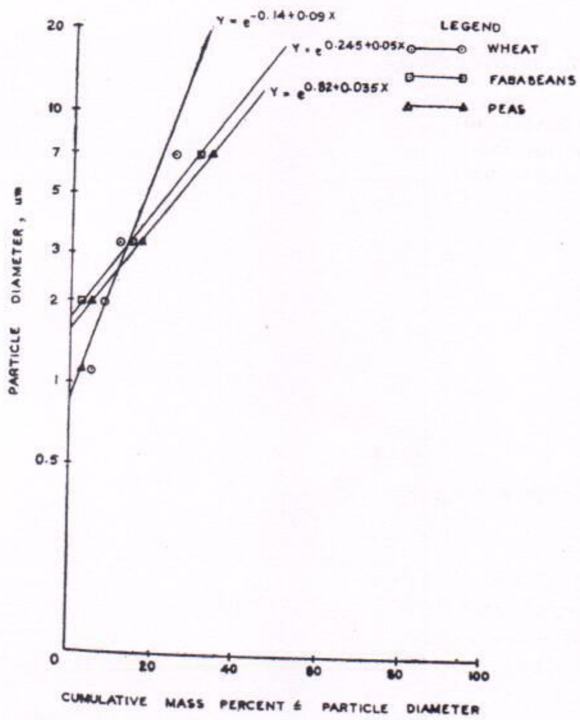

Fig. 4 *Particle size distribution of respirable dust in seed cleaning plants.*

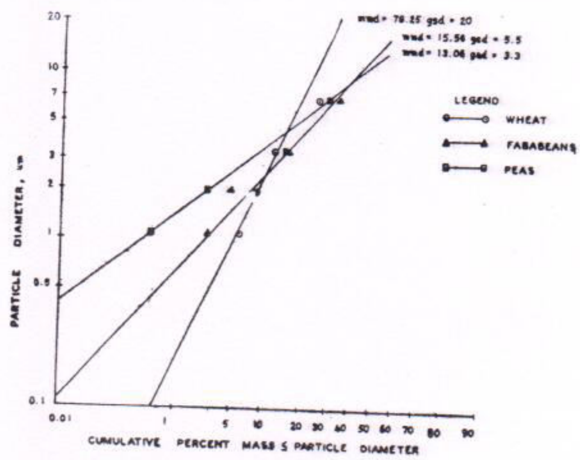

Fig. 5 *Particle size distribution of respirable dust in seed cleaning plants.*

(1976) also observed similar problems with the Andersen particle sizing head when the dust concentrations in the environment being monitered were high. It is, however, evident from Figure-5 that mass median diameters for fababeans and peas were 15.56 and 13.06 μm, respectively. These values are relatively close to the results obtained by Norman *et.al* (1977) for Sorghum dusts.

CONCLUSIONS

1. The amount of dust generated in the seed cleaning plants depended on the type of seed grain cleaned and the sampling location.
2. Four out of eleven seed cleaning plants surveyed had air pollution problems with dust levels reaching upto 114.23 mg/m^3.
3. The particle size distribution of grain dust followed a log-normal distribution.

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Use of Lichens in Air Pollution Studies

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The impoverishment or absence of lichens in cities and industrial areas is a pollugenic phenomenon. The air pollutant-induced responses of lichens, as of any other plant, are inhibitions of photosynthesis, respiration, growth, reproduction, and several other metabolic processes. Studies indicate that the pollution sensitivity level of lichens is relatively higher than that of other plant groups, because of the very delicately balanced symbiosis between the phyco-and myco-symbionts and for the extreme vulnerability of the phycobiont to air pollution injury. Therefore, the pollution indicator potential of these organisms is more than significant and their use as biological indicators of air pollution is strongly recommended.

LICHEN ENTITY : NATURE AND PHYSIOLOGICAL CHARACTERISTICS

Lichens are formed by an association of a fungus and an algae. The fungus, with a few exceptions, belongs to the group ascomycetes, while the algae may be green or blue-green. The composite plant or the thallus may be crustose, foliose or fruticose. The algae in most lichens form a layer enclosed on both sides by fungal layer which has no protective cuticle. In such a condition the water content of the whole lichen thallus remains in equilibrium with the surrounding environment. Such plants are termed poikilohydric, Richardson and Nieboer[1]. They dry quickly under sunny conditions, becoming more or less physiologically inactive, but reviving when remoistened, Smith[2]. Water uptake occurs very rapidly and lichens may hold several hundred percent of their dry weight of water. As a consequence, under damp conditions toxis substances dissolved in rain water have ready access to cells within the thallus. The presence of pollutants may be reflected in a reduced capacity of lichens for photosynthesis, or for nitrogen fixation in the case of those species containing blue-green algae, Hawksworth and Rose[3], Stewart[4]. However, when dry, lichens are less suceptible to the harmful effects of gaseous pollutants.

Another characteristic of lichens in their capacity to accumulate substances from their environment, by processes including active uptake of anions, passive adsorption of cations by an ion-exchange process and trapping of particulates. Collectively, these mechanisms result in lichens from urban-industrial area having higher levels of pollutants such as, sulphur and various heavy metals as compared with samples from rural environs. Particulate trapping is a major mechanism by which the lichens accumulate substances. Scanning electron microscope studies have revealed that the surfaces of many lichens have numerous tiny holes through which particles can enter the interior of the thallus and get lodged among the fungal strands of the medulla[5].

The lichen thallus, comprising an autotrophic alga and a heterotrophic fungus is a unique symbiotic organism. The laboratory synthesis of a lichen thallus has been a persistent failure because of the poor understanding of the extremely delicate physiological balance existing between the phyco and the mycobionts[6]. Lichen thalli produce numerous extracellular, aromatic and water insoluble substances which help lichens obtain metallic ions from their substrates, increase cell permeability of the phycobiont, enhance light absorption to stimulate photosynthesis[7], and inhibit bacterial and mold activity in the thallus[8].

LICHENS IN URBAN-INDUSTRIAL ENVIRONMENTS

Naturalists noted the effect of urban environment on lichen growth even in the last century. Nylander[9], after seeing the poor growth of epiphytic lichens in the city of Paris, commented that lichens are a sensitive "hygienometer" and can give a measure of the air quality of a place. Arnold[10] attached epiphytic lichens onto trees in the city of Munich and observed their death subsequently. Tobler[11] demonstrated that cultivation of lichens in the city atmosphere was possible only in filtered air.

The paucity of lichens in urban environments has been attributed to air pollution and dryness. LeBlanc and Rao[12] evaluated the two hypothesis and concluded that air pollution is the main factor responsible for elimination of lichens from urban habitats. There is an overwhelming body of evidence to suggest that lichens are highly sensitive to air pollutants and these organisms show great potential for pollution monitoring.

LICHEN'S RESPONSE TO AIR POLLUTION

Phytosociological and ecophysiological methods are used to study the air pollution effects on lichens[13]. The presence and absence of species, their number, frequency and coverage, and external and internal injury symptoms are related to the level of air pollution prevailing in an area to ascertain the purity of its air environment. Frequency of a species in a community is its percentage occurrance, coverage is the percentage area it occupies and density is the average number of individuals present in an unit area. In addition, other parameters, such as periodicity, vitality, fertility, etc., can also be taken into account. With the help of these parameters of species from specific substrates, such as, tree bark, the level of air pollution of an area can be estimated by correlating the lichen growth performance with the pollution concentration gradient on a line transact, stretching downwind from polluted to unpolluted zone. A number of workers have mapped polluted areas on the basis of lichen distribution and they have derived poleotolerance indices and biological scales for approximation of air pollution levels of isoecological areas.

Skye[14] correlated the epiphytic lichen growth pattern around an oil refinery in Sweden with the air pollution levels in the area and observed a weaker growth of lichens near the refinery in comparison to those in a control area 16 km away. He also noted a close conformity between the patterns of air pollution and lichen distribution. Beschel[15], Barkman[16] and LeBlanc and De Sloover[17], using several phytosociological parameters of epiphytic lichens, prepared distribution maps indicating the exact spatial limits of numerous lichen species growing in polluted areas. Rose[18] correlated the distribution pattern of epiphytic lichens *Anaptychia ciliaris*, *Parmelia caperata*, *Parmelia parlata*, etc., with the mean SO_2 levels and observed that the inner limits of species in their distribution map indicated the average levels of ambient SO_2. Likewise, Morgan-Huws and Haynes[19] observed a direct relationship between the annual average SO_2 levels and zonation of lichen flora in Fawley, England.

(a) Phytosociological Methods : Biological Indices and Scales.

Several workers have circumscribed polluted areas into several pollution zones on the basis of phytosociological investigations of epiphytic lichens. Sernander[20], first to attempt such a vegetation-pollution map, delineated three lichen zones in Stokholm, Sweden. He introduced the term "lichen desert" to describe situations when lichens are absent, as in city centres. Outside such barren zones, the lichen flora is much reduced in diversity and abundance, and he referred to this as the "struggle zone". Beyond this, where lichens thrived in an unpolluted air, was the "normal zone". These lichen zones correspond respectively to areas having maximum, moderate and minimum pollution levels. Rao and LeBlanc[21] have shown that in case of a point source of pollution, these lichen distribution vis a vis pollution zones take an elliptic shape in the direction of the prevailing wind; the axis of the ellipse extending from southwest to northeast direction, with the source of pollution being at the southwest end.

Taking advantage of gradation in pollution sensitivity of epiphytic lichens, lichenologists developed biological scales and indices for estimating air quality by relating the occuraence of indicator lichen species with known SO_2 levels. De Sloover and LeBlanc[22] and LeBlanc and De Sloover[17], developed a more sophisticated method to calculate indices of atmospheric purity (IAP) based on the number and abundance of epiphytic lichen species. The IAP-method assess the degree of air pollution using the formula :

$$IAP = \sum_{i=1}^{n} (Q \times f)/10$$

when i is a running species number with values of 1 to n, n being the total number of epiphytic species present at a given site; Q is the ecological index of a given species expressed by the average number of other epiphytes occurring with it at all the investigated sites; and f is the frequency-coverage of each species at the site. The frequency is the proportion of trees on which an epiphytic species is physically present at a given site and the coverage is the surface area colonized by the species at the site. Both frequency and coverage are assessed as percentage during data collection. From the frequency coverage data, f is assigned a numerical value on a scale of 1-5 for each species. A value of 1 represents a species that is very rare and has a very low coverage; 5 represents a species which is very frequent, with a very high coverage, LeBlanc *et.al.*[23]

IAP-values are calculated for each site and may be plotted on a map of the area under study. Zones are delimited by IAP-values which fall in the range 1-24, 25-49, 50-74, and > 74 and these are drawn by isometric lines. The IAP method makes possible the determination of areas of high and low atmospheric purity around pollution sources. This technique has been used to delineate pollution zones around copper smeltery, iron works, metropolitan areas, etc., in Europe and Canada. The IAP zones may be correlated with specific atmospheric SO_2 concentrations. The IAP method is also of considerable value in environmental impact studies which seek to establish baselines prior to the establishment or expansion of an industry in a rural area. Arrangements are made for the reexamination of the area at intervals after the start of the industrial activity. If changes are revealed in the epiphytic lichen communities it is possible that pollution control standards are not high enough.

Gilbert[24] studied lichens growing on sandstones, tree bark and old asbestos roofs and arranged them into six groups on the basis of their tolerance to SO_2-levels. By using this scale he concluded that large areas of countryside in England experience 45 ug/m^3 or 0.015 ppm SO_2 yearly on the average. Hawksworth and Rose (1970) produced a 10-point scale by grading epiphytic lichens with respect to their SO_2-tolerance. Similar list of epiphytic species have been presented by LeBlanc *et.al.*[25] Such scales can be used for estimating pollution levels in isoecological areas.

(b) Ecophysiological and Bioassay Methods : Morphological, Anatomical and Physiological Analyses

Lichen transplant studies under field conditions : To relate pollution load from an emission source to the lichen response, epiphytic lichens from unpolluted sites are transplanted along with bark onto trees in polluted sites. In such experiments, corticolous lichens are punched out along with the substrate without injuring the lichen and then carefully attached to host trees in polluted areas. After a convenient period of exposure, say 4, 6 or 12 months, the transplants from polluted end nonpolluted site are compared with respect to injury symptoms and morphological and anatomical changes. Such transplant studies have been made by Brodo,[26,27] LeBlanc and Rao,[28] Schonbeek,[29] Pyatt,[30] Hawksworth,[31] LeBlanc and Rao[32] and LeBlanc *et. al.*[33].

Macro and microscopic studies reveal that the external and internal changes in the transplanted lichen thalli closely resemble to those of SO_2-exposed lichens under laboratory conditions.[34] Since different levels of SO_2 produce different sets of external and internal injuries in lichens Leblanc and Rao[32] suggested that average SO_2-concentrations above 0.154, between 0.087 and 0.154, and below 0.042 ppm can respectively produce acute, chronic, and subtle injuries in lichens. Also, infra-red colour film can be used for assessing the health of transplanted lichens. Recently Kauppi[35] using infra-red photography has shown that the tips of healthy thalli appear red and the algal layer show-up blue, but the damaged thalli exhibit a blue colour with infra-red colour film. It has been found that the water content of the lichen thallus does not effect the infra-red film colour as it does the normal ectachrome colour film. The infra-red colour film is perhaps more suitable for demonstrating pollution induced changes in lichen thalli.

The transplant method has also been used to study the effects of fluoride pollution on lichens. Nash[36] transferred terricolous lichens *Cladonia cristatelle*, and *Cladonia polycarpoide* and saxicolous species *Parmelia plittii* from their natural environment to a point near a flouride source and observed chlorosis and eventual disintegration of their thalli after 3 months. The F-contents of transplanted flouride-exposed lichens ranged from 174-200 ppm in contrast to 8-28 ppm of the control. Similarly, LeBlanc *et.al*[37] transplanted epiphytic lichen *Parmelia sulcata* in a fluoride polluted area in Canada and after 12 months of exposure noted complete destruction of chlorophyll, plasmolysis cellular abnormalities, and high F accumulation in the transplanted lichen. Such injuries in lichen transplant have been confirmed by exposing lichens to specific pollutants under laboratory conditions.

By employing transplant technique, lichens may even be used for monitoring areas where naturally occurring thalli are absent due to existing or former pollution levels. In such situations either bark cores with lichens or fruticose lichens, such as *Cladonis stellaris* in small nylon nets may be fixed on trees. After the requisite time interval of a few weeks or months, the lichens are examined for elemental content and anatomical and physiological changes.

(c) Lichen Exposure to Air Pollutants under Laboratory Conditions to Establish Cause-Effect Relationship

Bio-assay of lichens exposed to a known concentration of pollutant helps correlation of injury symptoms with pollution level. Physiological and biochemical analyses of SO_2-and HF-exposed lichen thalli have helped establishing cause-effect relationships more precisely. The effects of SO_2 lichens under laboratory conditions have been studied in three different ways by exposing lichens to SO_2 (i) in closed vessels[34,38], (ii) in continuous flow-chambers[36,39] and (iii) in aqueous solutions of SO_2[40,41].

Pearson and Skye[38] in SO_2-exposed *Parmelia sulcata* thalli noted morphological and photosynthetic abnormalities similar to those of lichens collected from polluted areas and they suggested that SO_2 present in the urban air-shed could destroy chlorophyll of lichens growing there. Subsequently, Rao and LeBlanc[34] exposed several species of lichens to 5 ppm SO_2 for 24 hours at different relative humadities and observed bleaching of chlorophyll, permanent plasmolysis and necrotic spots on the chloroplast surface of *Trebouxia*, the algal symbiont of the treated lichens. Then injury symptoms were aggravated at higher relative humidities. They detected sulfurous acid and Mg^{2+} in the acetone-extract of SO_2 exposed thalli, the chlorophyll extract of which showed maximum light absorption at 667-nm wavelength, an absorption peak characteristic of phaeophylin *a*. The algal pastur in lichens is specially vulnerable (sensitive) to air pollutants, such as SO_2 and this seems reasonable as most of the water present in a nonsaturated lichen thallus is held in the algal layer which would favour maximum SO_2 reaction[42]. A rapid assessment of the condition of the algal cells may be made by examining fresh sections of lichen thalli with a fluorescence microscope. Healthy cells excited by an appropriate form of short wave radiation emit a powerful red radiation due to the emission capacity of chlorophyll. Increasing damage results in the algal cells exhibiting red through brown and orange to yellow and finally white fluorescence. By calculating the percentage of cells exhibiting the various types of fluorescence it is possible to determine the degree of damage in a particular lichen sample[35]. This technique is likely to supersede the extraction and quantitative estimation of chlorophyll by spectrophotometry as it is easier and not subject to difficulties induced by the lichen acids during extraction.

Hill[40] studied the effects of SO_3^{2-}, an oxidation product of SO_2, on the photosynthetic carbon fixation of certain lichen species, which were highly, moderately, and least sensitive to SO_2 pollution. He observed that the photosynthetic responses of these lichens to sulphite solution matched their relative sensitivity to air pollution as noticed in the field.

Puckett *et.al*[41] studied the effects of SO_2 in aquous solution on net photosynthesis, using radioactive sodium bicarbonate and observed a temporary inhibition in photosynthesis with subsequent recovery. It has been seen in lichens the SO_2-sensitivity of photosynthesis is 3-5 times greater than that of respiration[43]. According to Pearson[44] there exists a significant correlation between the degree of SO_2 pollution and the change in amino acids of lichens. He found that the amino acid composition (especially of cystine) of the Protein of *Lacanora melanophthalma* decreased in direct proportion to the degree of air pollution.

LICHEN REPRODUCTION AND FERTILITY REDUCTION BY AIR POLLUTION

Air pollution inhibits not only growth but also reproduction of lichens. Pyatt[30] observed that in many lichen species the ability to produce viable ascospores and soredial and isidial structures decreased with increasing levels of pollution. De Sloover and LeBlanc[45] observed an increase in lichen fertility with decrease in pollution level. LeBlanc *et.al.*[37] and LeBlanc and Rao[32] observed absence of soredial and isidial structures in lichens of polluted areas. According to them the extent of soredial development is a function of the degree of air purity: the purer the air the greater the soredial development. In view of the inhibitory effects of air pollution on reproduction of lichens, it could be suggested that the degree of success of a lichen species in polluted areas would largely depend on their reproductive potential in such environments. It may be said that active metabolism, high reproductive capacity and fast growth may enable lichens to resist pollution. However lichen are notoriously slow-growing organisms and their growth performance in polluted air is slower still. The lichen propagules soredia and isidia will also be seriously affected when exposed to pollutants and the phycobiont, which is most vulnerable to air pollutants, will fail to multiply in polluted air and thus the formation of a thallus from a propagule may not be accomplished.

LICHENS' DIFFERENTIAL SENSITIVITY TO AIR POLLUTION

Lichen species exhibit considerable variation in their susceptibility to air pollution. Though majority of lichens cannot survive in polluted air, nevertheless, some species do manage to live and grow even in polluted environment. Such species are either toxitolerent, taking advantage of the reduced competition or toxiphillous, being nutritionally stimulated by certain air pollutants present in the urban industrial environment. For example *Stereocaulon pileatum*,[46] *Lecanora conizaeoides*[47], *Buellia punctata, Candelariella aurella, Lecanora dispersa*[48], *Bacidia chlorococca, Endocarpon pusillum*[17] and *Micraria trisepta*[36] appear to be toxitolerant species. Similarly, *Lecanora conizaeoides* derives some nutritional benefit from SO_2 polluted environment and it may be regarded as toxiphillous[30,47,48].

The sensitivity level of a lichen species may differ for different pollutants. For example, the SO_2 sensitive *Usnea floridana* is found to be resistant to flourides[49]. Some species may be equally tolerant to different pollutants, such as, *stereocanlon pileatum* can establish itself on the spoil heaps of copper and lead mines as well as in the SO_2-and HF-polluted areas[46,49]. Such toxitolerant species could be pioneer colonizer of a variety of polluted habitats which may be inhospitable for the growth of other lichens. It is the pollution sensitive lichens which are suitable for indication and monitoring of air pollution. Among lichens, the fruticose ones are most sensitive, foliose ones moderately sensitive and the crustose ones least sensitive to air pollution.

LICHEN RESPONSE AND SUBSTRATE-ENVIRONMENT RELATIONSHIPS

Air pollutants affect lichens both directly by causing toxicity to already established thalli, and indirectly by rendering the substrates unfit for establishment of their vegetative propagules. The level of lichen response to a given pollutant may be moderated by physicochemical properties of the substrate and growth-form of the lichen thallus. The sensitivity of a lichen species to an air pollutant is closely related with the buffer capacity of its substrate. Species occupying acidic substrates are usually more sensitive to SO_2 than those on basic substrates. With respect to substrates, the sensitivity increases from terricolous to saxicolous to corticolous lichens.

As the species growing on tree trunks exhibit far greater sensitivity to air pollution than those occurring on other substrates, the epiphytic lichens are therefore uniquely suited for purpose of air pollution monitoring. Among epiphytes, the lichens occurring on eutrophiated bark, such as elm, can tolerate higher doses of pollutant than those present on noneutrophiated bark of oak or ash.[50] This is especially true for *Xanthoria spp.*, which is a nitrophilous lichen. The greater tolerance of eutrophiated lichens to SO_2 may be attributed to alkaline and earth-metal contaminants trapped in the bark crevices, increasing the buffer capacity of the bark and the rate of oxidation of SO_2 to SO_4^{2-}.

The bases present in soil are acid-buffing and these oxidize SO_2 into$_4^{2-}$ within seconds, which in case of water and air-media may take hours. The moisture level in a lichen thallus can modify pollution effects linearly, that is the effect will be greater at higher level of moisture and vice-versa. Perhaps, the secret of the remarkable tolerance of *Lacanora conizaeoides* to SO_2 lies in the nonwetting property of its crustose thallus.[43] To some extent the growth-forms of lichens can also temper the effects of pollution. According to Gilbert,[48] the sensitivity increases from leperose, through crustose, folion and fruticose lichens.

LICHEN ACCUMULATION OF HEAVY METALS AND RADIONUCLIDES

Lichens are known to be efficient accumulators of heavy metals[51] and they have been used for monitoring the atmospheric deposition[23,52] of more than 30 elements including Cd, Pb, Hg, As, Mn, Fe, Ni, Cu, Zn, Sc, Li, Na, K, Mg, Ca, Sr, etc. Foliose or fruticose lichens are collected at increasing distance from the pollutant emission source or urban areas and the samples are cleaned and analysed by a suitable method, such as atomic absorption spectrophotometry, X-ray fluorescence spectrometry, or neutron activation. Elevated elemental levels are observed close to the source, which fall off quickly at first and then more slowly with distance along the transect[23]. In monitoring studies around a point source of pollution it has often been observed that there is a linear correlation between the elemental content of the lichen and the reciprocal of the distance from the emission source. In general, the absorption and accumulation of heavy metals in the lichen thallus is affected by its morphology, nature of substrate incidence of acid rain, proximity of the pollution source and microclimatic conditions. The overall effect on lichens of heavy metals is as unfavourable to them as that of gaseous pollutants. Some lichens, like *Stereocaulon*, remain unaffected by high concentration of heavy metals and this fact has prompted the use of lichens in mineral prospecting. Laaksovirta and Olkkonen[53] have shown that the lichen *Hypogymnia physodes* is a better accumulator of K, Ca, Ti, V, Fe and Zn than pine needles and that the lichen metal content agrees better with the pattern of prevailing winds.

Lichen thalli are also efficient accumulators of radionuclides. Aberg and Hunget[54] reported usually high levels of radioactivity in the tissues of Norwegian reindler. Subsequently studies revealed that Alarkan reindler had more than 20 times the levels of radioisotopes observed in cows grazing near the Navada nuclear test site. The radioactivity in the reindler was mainly due to the isotopes ^{137}Cs and ^{90}Sr, derived from lichen forage. Further confirmation came from the observation that when atmospheric testing was at its height, the ^{90}Sr content of cows' milk from Lapp farms in Finland, where lichens were used to supplement the feed, was 3-4 times higher, than milk from farms in centrol areas.[55] Because of their ability to concentrate radionuclides and their position in the food chains, especially of some arctic population groups like Lapps and Eskimos[56], the lichen communities must assume considerable importance in monitoring systems where information is needed on the extent and severity of fallout from nuclear detonations or on the waste discharge from nuclear reactions.

CONCLUSIONS

The use of lichens as air pollution indication and monitors has been recognized for some time, however, only recently the environmentally conscious agencies have begun to appreciate the value of these plants in air pollution studies. Elucidation of responses of lichens to air pollutants may help to a general acceptance of these plants in biological monitoring programmes. There is little doubt that today's sophistication in data collection, analytical techniques, and computer simulation, will encourage the use of these unusual plants to help man prevent environmental pollution.

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"Fly ash deposition and productivity measurements in Beans"

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The growth of crop plants in soils amended with fly ash deposition on leaves and its subsequent effect on the growth of beans are presented. Potted bean plants (*Dolichos lablab Linn*) placed in a chamber with open top for fly ash exposure. No injury symptoms or stomatal clogging could be noted but reduction in area of leaves was obvious. A spray dose of 4 gm $^{-2}$ day^{-1} of flyash resulted in an increase of chlorophyll content by 38.95 percent probably due to the shading effects. A negative correlation between chlorophyll content and production suggests that under longer duration of shading and severity of dusting this compensatory mechanism may not work.

INTRODUCTION

A number of thermal power stations in India are without scrubbers or electrostatic precipitators. The pulverised coal is the fuel used and apart from the gaseous pollutants, a good amount of flyash is released in the environment. The estimated amount of flyash released in the air through the stacks of Satpura Thermal Power Station at Sarni (M.P.) and Thermal Power Station at Nagda (M.P.) is 300 and 80 tonnes per day respectively, which could be fairly observed upto 15 km in the down wind directions.

Information regarding the effects of particulate matter of different origin are available i.e. fluoride dust, Mc Cune *et.al*[1]., Leblanc *et.al*[2]; cement dust, Darley[3], Parthasarthy *et.al*[4], Singh and Rao[5]; soot, Miller and Rich[6]; coal dust, Rao[7], Pawar *et.al*[8] and flyash mixed with soil, Page *et.al*[9]. However, very little information is available on flyash deposition and its subsequent effects, Bomhard[10], Sobotka and Materna[11], Kick and Grosse-Brauckmann[12]. The present study was designed to see the effects of fly ash deposition on the productivity in beans, (*Dolichos lablab* L).

EXPERIMENTAL MATERIALS AND METHODS

nA open top chamber of 0.5 m^3 capacity was fabricated by covering an iron frame from all the four sides by thin polythene sheets. Three earthen pots with one bean plant per pot, were placed in each chamber and a control was run simultaneously in a similar chamber.

Equal quantities of fly ash from the two mentioned power stations were mixed. Leaves of seven day old plants were exposed to fly ash by spraying it with a hand rotatory duster. Spraying rates were 1,2,3 and 4 g M^{-2} day^{-1} for 15 days. Dusted leaves were transferred to a conical flask containing 200 ml of water. After thoroughly shaking the water was filtered with a Whatman No 1. The filter was dried, weighed and fly ash deposition in gm^{-2} was computed. Leaf area was measured with a planimeter. Chlorophyll and carotenoids were estimated following Arnon[13] and Duxbury and Yentsch[14] methods respectively. Leaves were dried at 80°C for dry weight determinations.

DISCUSSIONS ON RESULTS

There was no morphological change in the exposed plants. Microscopic examinations has revealed that there was no clogging of the stomata. This may be due to the fact that fly ash does not form a crust like cement. Table 1 shows the reduction, in the leaf area to an extent of 40-50 percent. The dry matter production was upto 26 percent with the highest quantity of fly ash sprayed in these experiments. This reduction could be attributed to the shading effect, change in pH, as has been reported by Pierce,[15] Bomhard[10] for coal dust. According to Ricks and Williams[17] there is a reflection of the solar radiations of wavelength betwen 400 to 750 nm which reduce photosynthesis.

Table 1. *Area and dry wt. of Primary Cotyledonary leaves fly ash Sprayed*

Fly-ash dose	Area before spray	Area after spray	Change in area	% decrease in area over control	Dry wt. in gm^{-2} leaf area	% decrease in dry wt. over control
Control	26.6 ± 3.68	35.00 ± 4.86	8.33 ± 1.25	—	4.800	—
1 $gm^{-2}day^{-1}$	25.83 ± 4.00	30.67 ± 4.03	4.84 ± 0.26	42	4.390	9
2 $gm^{-2}day^{-1}$	28.67 ± 6.21	33.00 ± 6.26	4.33 ± 1.75	48	3.890	19
3 $gm^{-2}day^{-1}$	29.67 ± 4.72	33.66 ± 3.75	3.99 ± 1.50	52	3.600	25
4 $gm^{-2}day^{-1}$	27.83 ± 1.14	32.33 ± 2.21	4.50 ± 1.69	46	3.545	26

Table 2 shows the variation of chlorophyll with flyash concentrations. The increase in chlorophyll content was proportional to fly ash concentration. The total chlorophyll content increased by 9.97 and 38.95 percent with 1 and 4 g doses of fly ash. This increase is probably due to shading effect and can be explained with the observations that leaves growing in shade have more chlorophyll than growing in sun Misra *et.al.*[17] Lewandowska and Jarvis[18] mentioned that the variation in light intensities may also result in chlorophyll contents variations. From fig. 1 it appears to be a compensatory mechanism to produce more photosynthate but this may not prove satisfactory under severe dusting and longer duration of shading as there is a negative correlation between the increase of photosynthetic pigments and dry matter production. It is very likely that in absence of this mechanism perhaps leaves could have died earlier as the production would have been still lower. But at this stage it is interesting to note that the ratio between theoretical deposition (the amount which should deposit on leaf surface over fifteen days) and observed deposition was found to be 156:1 to 181:1, (Table 3) indicating

Table 2. *Pigment concentration of fly ash sprayed Bean Leaves Mg g^{-1} dry weight*

Rate of FA Spray	Chl.a	Chl. b	Total Chl a + b	% Increase Total Chl.	Carotenoids	% Increase in carotenoids
Control	2.49	1.72	4.21	———	1.35	———
1 $gm^{-2}day^{-1}$	2.66	1.97	4.63	9.97	1.39	2.96
2 $gm^{-2}day^{-1}$	2.77	1.93	4.70	11.63	1.47	8.88
3 $gm^{-2}day^{-1}$	2.93	2.51	5.44	29.21	1.71	26.66
4 $gm^{-2}day^{-1}$	3.66	2.19	5.85	38.95	1.83	35.55

Table 3 *Fly ash Applied and Deposition Over 15 Days Spray*

Cumulative spray ($g\ m^{-2}$) (Rate X days)	Leaf area (cm^2) receiving FA	Actual deposition on leaf (mg) (AD)	Expected Total deposition of FA (mg) (ETD)	ETD : AD
1 × 15 = 15	30.67 ± 4.03	28.61 ± 1.2	4.600	1 : 160.78
2 × 15 = 30	33.00 ± 6.26	54.61 ± 3.1	9.900	1 : 181.28
3 × 15 = 45	33.66 ± 3.75	85.30 ± 1.8	15.150	1 : 177.60
4 × 15 = 60	32.33 ± 3.21	124.00 ± 2.6	19.40	1 : 156.45

that a good amount of flyash is either dropped or released into the environment and only a small amount is retained on the leaf surface. This is the amount which is potentially responsible for the damage.

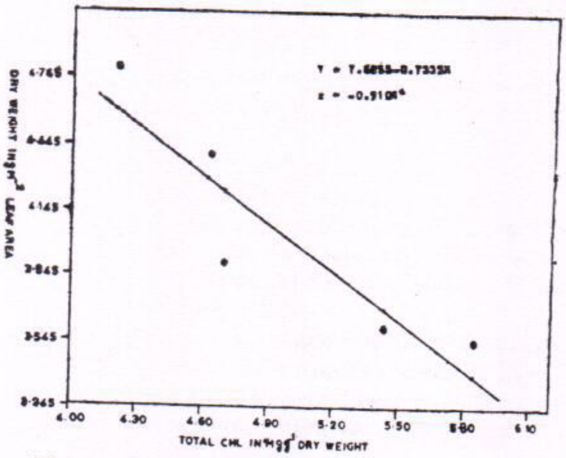

Fig. 1. *Showing the relationship between dry weight and total chlorophyll content of r-significant at 1% level*

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An experimental study on smoke elimination in a household sigri

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In an earlier study it was reported that the evolution of smoke in a household sigri (Chulha) mainly occured due to an initial large difference of temperature between the top and the bottom of the igniting fuel bed. In order to check whether smoke could be reduced or eliminated by reducing this initial temperature difference, an experimental study was undertaken where combustion conditions were simulated in a closed cylindrical apparatus with a provision for heating the top of the bed. The results of the study showed that if the initial smoke laden gases could be passed through a hot zone kept above certain temperature, the smoke could be completely eliminated.

INTRODUCTION

In a previous work on a household sigri (Chulha), the principal reasons of smoke evolution during the initial lighting up operation was established. From the results of the study it could be concluded that the generation of smoke was mainly due to initial large difference of temperature between the top and bottom zones of the fuel bed. An experimental study was undertaken to see whether initial smoke generation could be reduced or eliminated by raising the top temperature of the bed thereby reducing top-bottom temperature differences. In order to do so, combustion conditions were simulated in a closed cylindrical apparatus where the natural draught of air flow of a household sigri was replaced by an equivalent positive flow of compressed air. In order to verify whether smoke could be reduced or eliminated by decreasing the top-bottom temperature difference, the top-zone of the coke bed was externally heated by electric arrangements. The results so obtained are presented here.

EXPERIMENTAL SETUP

The apparatus for the experimental study was made out of a cylindrical silmanite tube, 32cms long and 4cms in diameter as shown in Fig.1. Two ends of the tube had flanged covers having inlet of air at the bottom and outlet of flue gas at the top through a square chimney of 1 cm x 1 cm cross section. Through two holes made on opposite sides of this chimney fitted with transparent glass windows the density of smoke could be measured in terms of voltage required to make a light bulb (60 watts) just visible with naked eye through the layers of smoke. Samples of flue gas passing through the chimney was collected for analysis from time to time. The lower part of the cylindrical tube was fitted with an internal electrical heater through which incoming air could be heated to 600°C which was sufficient to ignite the fuel bed. The fuel bed consisted of an igniter fuel such as wood chips or cowdung cake and the main fuel, coke; the ratio of the two were kept similar to that earlier used in the experimental sigri.[1] The fuel bed (1 gm of igniter fuel and 2.3 gms of coke) was supported on a grid made of stainless steel wire mesh placed above the air heater. On top of the fuel bed, leaving a gap of about 8 cm, a rolled gauge of stainless steel was placed which could be heated to different temperatures by placing in an external heating coil on the outside wall of the silmanite tube. A thermocouple placed through the top of chimney inside the rolled wire gauge measured the temperature of this zone.

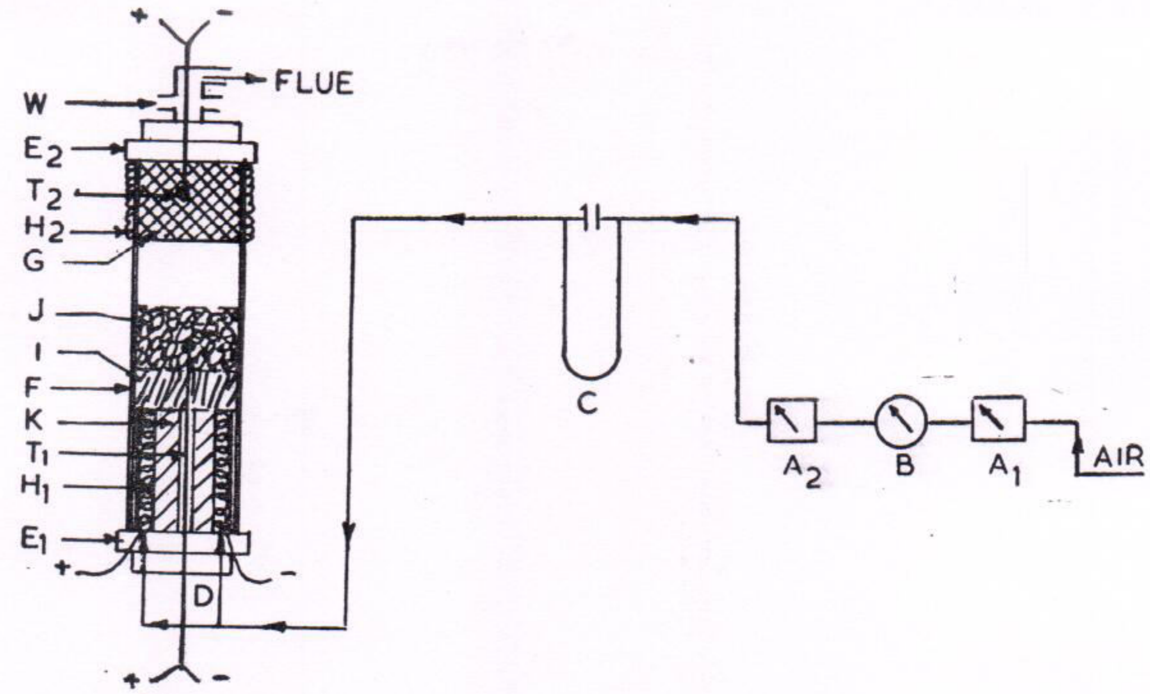

Fig. 1. *Experimental set-up*

Legend

A_1 , A_3	— Needle valves
B	— Pressure gauge
C	— Orifice meter with H_2 manometer
D	— Entry of air point
E_1 , E_2	— Thermocouples
F	— Tube (Reactor)
G	— Rolled Stainless steel wire mesh
H_1 , H_2	— Heaters
I	— Igniter Fuel (wood or cowdung)
J	— Coke bed
K	— Steel wire gauge (grid)
W	— Transparent window

In each set of experiment, first the fuel bed was arranged and both the electrical heaters were used without airflow, to indicate lower temperature at 60°C and upper temperature at a desirable value not exceeding 300°C. Then as the air flow started, both the temperatures were changed with time. Temperature of the bottom fuel bed usually reached round 850°C and the top temperature varied with time depending on the particular run and the initial top temperature. The temperatures were continuously recorded with a multipoint recorder.

The flow rate of air was adjusted according to an initial estimate of theoritical air taking total time of combustion in an actual sigri earlier used; from this value of air, flow rate was reduced according to the ratio of cross sectional area. *For the present apparatus, the estimate of air flow was found out to be 1.6 litre per minute at ambient temperature and pressure. However, flue gas analysis, was carried out with orsat apparatus and it was found that 46 percent air was excess.* This was mainly due to reduction of height in the fuel bed in the present set-up than what was used with the experimental sigri. A few experimental runs were conducted with air flow varying between 1.16 litres and 1.8 litres/minute. It was observed that steady burning of fuel bed could not be sustained below a flow rate of 1. 6 litres/ minute. Following this, all the experimental runs were conducted with this value of air flow rate fixed.

Each experimental run was found to have a duration of 20-25 minutes. Two temperatures were continuously recorded on a recorder. Smoke density was measured every 30 seconds as carried out earlier[1]

RESULTS AND CONCLUSION

The results of the experimental study showed that the bottom zone temperature for each experiment was nearly same for all experiments. A typical figure of the variation of smoke density with the top-zone temperature for wood and coke is shown in Fig. 2. Because of varying top temperature, smoke density could not be compared properly at different fixed top temperatures. For the sake of comparison, the temperature at the maximum smoke point was chosen for each experiment and plotted against the smoke density at this point. In Fig. 3 it was observed that maximum smoke density decreased uniformly with rise of top temperature assymptotically reaching a negligible value around 500°C. From this observation it could be concluded that a temperature of 500°C at the top zone is required for elimination of smoke.

Further experiments with a modified sigri are in progress where the generated smoke can be passed through a hot zone for its reduction and elimination.

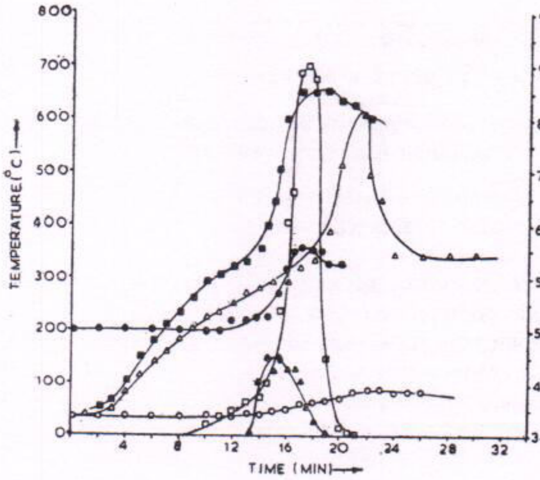

Fig. 2. *Variation of smoke density and temperature with time*

Legend Top zone at 35°C (room temp.)
△△ — Top zone temperature
⊙⊙ — Bottom zone temperature
□□ — Smoke Density
Top zone at 200°C
□□ — Top zone temperature
○○ — Bottom zone temperature
△△ — Smoke Density

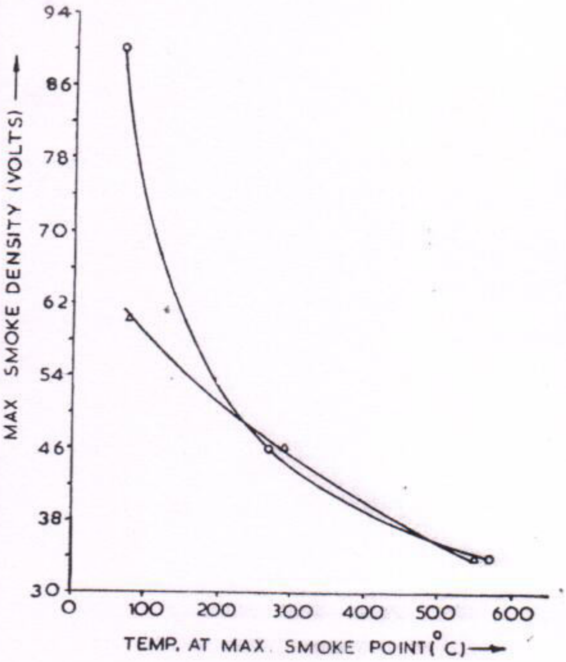

Fig. 3. *Plot of maximum smoke density versus temperature at max. smoke point*

Legend ○○ — Wood + Coke
△△ — Cowdung + Coke

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Foliar Injury to Trigonella Foenum-Graecum due to Sulphur Dioxide Exposure

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Effect of 3-hour fumigation with 1.0, 0.5, 0.09 and 0.04 ppm concentration of sulphur dioxide on the leaves of 15 and 30-day old plants of *Trigonella foenum-graecum* were studied under laboratory conditions. The parameters used to assess the effects were chlorophyll contents and leaf area damage of fumigated plants. Since it was noticed that leaves of different ages responded differently, three size classes of leaves were studied separately.

INTRODUCTION

Leaf injuries of different types and of varying intensities caused by industrial effluents have been recorded by Chaphekar[1] in Bombay city. The extent and type of injury caused to leaves exposed to different concentrations of sulphur dioxide have been reported by many workers, Brandt and Heck[2] David[3], Banerjee and Chaphekar[4] and Boralkar and Chaphekar[5] reported injury to many plants due to SO_2.

MATERIALS AND METHODS

Seeds of *Trigonella foenum-graecum* L. obtained from an authorised seed dealer were sown in 20 cm diameter earthen pots containing especially prepared soil comprising red laterite loam-90% and farmyard manure-10%. After 8 days, thinning was done, keeping 10 plants per pot. Plants of five pots for each concentration were exposed to 1.0, 0.5, 0.09 and 0.04 ppm SO_2 for 3 hours separately, in a fumigation chamber, Banerjee, et al[6]. After a period of 24 hr, estimations for total chlorophyll, chlorophyll *a*, and chlorophyll *b* were done by following the methods of Arnon[7], also measurements of injured leaf area was made, using transparent graph papers. Leaves were grouped on the basis of size into small (< 50 mm^2), medium (51 to 100 mm^2) and large (> 100 mm^2) for the assessment of injury at different ages of leaves.

RESULTS AND DISCUSSION

From the results of leaf area injury as given in Tables 1 and 2, it is apparent that the extent of injury of 15-day old plants at 1.0 ppm was 83%, which decreased at decreasing concentrations. Similarly, the leaf area injury of 15-day old medium leaves at 1.0 ppm was 81% and that at 0.5 ppm it was 40%. At 0.09 and 0.04 ppm concentration, the leaf area injury was 31 and 23.5% respectively. In the case of 15-day old large leaves the leaf area injury was 56% at 1.0 ppm and 37, 20.5 and 14% at 0.5, 0.09 and 0.04 ppm, respectively. The total leaf area injury of all 15-day old leaves was 78.2% at 1.0 ppm, 42% at 0.5 ppm, 20.4% at 0.04 ppm and 20.6% at 0.09 ppm concentration. Thus, the small leaves of 15-day old *T. foenum-graecum* plants showed maximum leaf injuries at all SO_2 concentrations as compared with those of medium and large sized leaves.

Injuries to small leaves of 30-day old plants at 1.0 ppm was 42% and at 0.5 and 0.09 ppm 35 and 21% respectively. The leaf area injury for 30-day old medium leaves at 1.0, 0.5, 0.09 and 0.04 ppm concentrations were 31, 17 and 14%, respectively. Similarly, the large leaves of 30-day old plants had leaf area injury of 20% at 1.0 ppm concentration and 18.9, 16.5 and 13% at 0.5, 0.09 and 0.04 ppm concentrations, respectively.

It is seen from the above results that small leaves

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Table 1 : *Effect of a 3-hour SO_2 fumigation at 1.0,0.5, 0.09, and 0.04 ppm concentrations on leaf are injury and chlorophyll contents of 15-day old Trigonella foenum-graecum plants.*

SO_2 Concentration (ppm)	Leaf Area Injury (%)				Chlorophyll (mg/g fresh weight)			Chlorophyll a/b
	Large (100mm²) & more	Medium (51 to 100 mm²)	Small (less than 50 mm²)	Total	Total	*a*	*b*	
1.0	56	81	83	78.2	0.956	0.591	0.350	1.6
0 5	37	40	80	42	1.61	0.879	0.695	1.2
0.09	20.5	31	66	20.6	3.32	1.59	1.62	0.9
0.04	14	23.5	46	20.4	6.25	3.21	2.87	1.1
Control	—	—	—	—	6.65	3.22	3.39	0.95

Table 2 : *Effect of a 3-hour SO_2 fumigation at 1.0, 0.5, 0.09 and 0.04 ppm concentration on Leaf are injury and chlorophyll content of leaves of 30-day old plants of Trigonella foenum-graecum.*

SO_2 Concentration (ppm)	Leaf Area Injury (%)				Chlorophyll (mg/g fresh weight)			Chlorophyll
	Large (> 100mm²	Medium (51 to 99 mm²)	Small (< 50 mm²)	Total	Total	*a*	*b*	*a/b*
1.0	20	31	42	28	6.04	2.11	3.69	0.5
0.5	18.9	30	35	25.3	7.99	3.42	4.28	0.79
0.09	16.5	17	21	17.5	8.50	3.66	4.55	0.8
0.04	13	14	17	14.4	9.71	3.91	5.42	0.72
Control	—	—	—	—	9.92	4.00	5.54	0.7

of 30-day old *Trigonella foenum-graecum* plants showed maximum injury at all concentrations of SO_2. Medium leaves showed injury above 30% at 0.5 and 1.0 ppm concentrations.

It may be concluded from the above that 15-day old plants were more susceptible to SO_2 than the 30-day old ones, and the small leaves of 15-day old plants showed maximum injury at all SO_2 concentrations as apparent by the injury index values which were more in 15-day plants than in the 30-day old plants.

The total chlorophyll content in 15-day old leaves exposed to 1.0 ppm SO_2 was 0.956 mg/g fresh weight but the same continuously increased at decreasing levels of SO_2. The control leaves of 15 and 30-day ages had the total chlorophyll contents of 6.65 and 9.92 mg/g fresh weight respectively.

The 15-day old leaves suffered a higher loss of chlorophyll than the 30-day ones, at all levels of SO_2 exposure.

The degradation ofchlorophyll *a* i nto phaeophytin *a* has been reported by Rao and LeBlanc[8]. This degradation process is initiated by H_2SO_3 at low pH of 2.3. In the present study perhaps the reduction of total chlorophyll was due to such degradation of chlorophyll. It was noticed that the injury to individual chlorophyll pigment was not selective at lower SO_2 concentrations, at both the ages of plants tested. At concentrations of 0.5 and 1.0 ppm however, the a/b ratio went on increasing gradually in younger plants, indicating higher loss of chlorophyll *b*.

CONCLUSION

The *Trigonella foenum-graecum L.* plants were found sensitive to SO_2 fumigation at 1.0, 0.5, 0.09 and 0.04 ppm concentrations for three hours at 15 and 30-day ages. The 15-day old plants were more sensitive than the 30-day old ones. The leaf area injury and chlorophyll loss increased at increasing

SO_2 concentrations. The leaf area injury was greater in younger than older leaves.

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Some Aspects of Emission Standards and Ambient Air Quality Survey

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After the enactment of "The Air (Prevention and Control of Pollution) Act, 1981, in India, increasing awareness has been created among the industrial sector about the measures to be adopted for quantification and control of Air Pollution. Implementing Authorities on the other side, are considering it as an effective tool to dictate the industry for bringing down emission levels. Air Pollution in and around industry will be reduced only if this law is effectively enforced without over-looking the purpose behind it. Implementing authorities will have powers to lay down emmission standards under Chapter III Section 17 (i) of (g) of the Act and powers to inspect, check, analyse the effluents arising out of control equipment as well as pollution sources, under sub-section (e) and (f) of Chapter III, Section 17 (1) of the Act.

While setting up the emission standards one will have to bear in mind that normally Air Pollution arises due to fuel burning sources and due to emissions of reactive gases.

EMISSION STANDARDS FOR FUEL BURNING SOURCES

While considering the emission standards for fuel burning sources, it will be worthwhile to ask data regarding composition/Analysis of gaseous pollutants only for those pollutants which are needed to be controlled. For example, in the case of Boiler Flue Gases, when concentration of gaseous pollutants like SO_2, NO_x, H_2S etc. is directly dependant on the chemical composition of the fuel i.e. Sulphur and Nitrogen content in the fuel, it is not necessary to ask SO_2, NO_x, H_2S concentration in boiler flue gases and especially when, after obtaining such data, implementing authorities are not going to direct the industry to reduce the concentration of the above pollutants. It will not be practicable especially for small boilers/Thermopacs having furnace oil consumption upto 10 metric tonnes or equivalent coal consumption per day to ask to reduce SO_2 emissions from flue gases by "Desulfurization" techniques. Hence while asking the data for granting consent to emit boiler flue gases, upto above fuel consumption, composition of only following parameters should be asked unless otherwise, data is required to design pollution control equipment.

(1) Temperature
(2) Emission Rate
(3) Opacity or Ringle-man Number or Smoke Density
(4) Concentration of Suspended Particulate Matter
(5) Carbon Dioxide Percentage

The data regarding the analysis of any pollutant other than the above will not serve any useful purpose. Then, in the case of Boiler flue gases emission standards required will be for (i) Particulates (ii) Opacity (iii) Carbondioxide percentage.

It may be noted that "Boilers used in Thermal Power Plants" need special attention. If there is a thermal power plant in the near-by vicinity say around 20 km.; and if no preventive steps for reduction of SO_2 and particulate emission are being taken then it would be a futile exercise to ask to reduce SO_2 and particulate emissions from other smaller multiple sources, though there may be thousands of them. This may be true, especially in Bombay. If the implementing authorities are not considering to take adequate steps to reduce SO_2 and particulate emissions from existing and new coming thermal power plants, then it will be futile to ask other industries, whose pollution potential is far less than that of thermal power plants, to reduce particulate or SO_2 pollution by installing control equipment like scrubbers to reduce SO_2 from such thousands of small sources. In fact such an action may create health hazards by way of creating problems of water pollution rather than improving the atmospheric pollution in surrounding areas. It is felt that effective Air Pollution Prevention in comparatively large sources will be more purposeful. "Dispersal at higher altitudes" technique may be adopted in the case of such smaller sources like Boilers upto 10MT. of furnace oil consumption per day.

Coal fired thermal power plants need special attention while deciding emission standards. While no difficulty is foreseen either in prescribing standards or in controlling emissions of particulates in coal fired thermal power plants, it will be difficult to control SO_2 from coal fired thermal power plants. E.P.A. standard for coal fired thermal power plants with 0.6% sulphur-content in coal has been described as 0.15lbs/106 B.T.U. heat input. We will have to decide std. for SO_2 on similar guide-lines for Indian Coals.

While prescribing emission standards for reactive gases like, Chlorine from Chloralkali manufacturing plants; ammonia from fertilizer plants; hydrogen sulphide and carbon disulphide from Rayon manufacturing plants; sulphur dioxide, sulphur trioxide, oleum and H_2SO_4 mist from sulphuric acid plants and sulphation processes; oxides of nitrogen from nitric acid plants and nitration processes etc, we will have to bear in mind that these reactive gases create primarily "local pollution" and cause uneasiness or discomfort in the nearby residential localities, especially under unfavourable meterological conditions. Therefore it will be desirable to impose stricter emission standards for such reactive gases. Such standards may be prescribed taking into consideration the number and size of polluting sources of particular reactive gas in the area and it's threshold concentrations in Ambient air. Pollution control techniques like "wet-scrubbing" will have to be imposed on such pollution sources, irrespective of the cost incurred for control equipments.

Thus it will be essential to apply our mind for preventing pollution from reactive gases as well as that from thermal power plants or from boilers having furnace oil consumption more than 10 M.T./day or equivalent coal consumption.

It will be essential to invite attention of the experts towards planning and execution of 'ambient air quality' surveys. Nation-wide ambient air quality surveys will be conducted in near future, basically with a view to find out ambient air quality levels for better land use planning. Nation-wide guidelines about the method and manner as well as equipments to be used in the survey, need to be indicated by the Central Board for Air Pollution prevention and control.

At present, mobile air quality monitoring laboratories with automatic recording systems for SO_2, NO_x, particulate pollutants are available for ambient air quality survey in addition to high volume sampling techniques alongwith wet chemistry methods for detection of various air pollutants. Advantages with the mobile monitoring system is that since the data is automatically analysed and recorded, it will be independent of personnel errors. However the system has following disadvantages :

(i) The cost involved for mobile monitoring is very high and it also requires foreign exchange.

(ii) Technical expertise is essential to maintain and monitor such laboratories.

(iii) Possibility of interference be local pollution created due to "generate set" cannot be eliminated or overlooked.

(iv) Ambient air quality upto heights of only 3 metres or so can be recorded unless otherwise special arrangements are made to take samples from elevated heights.

(v) Failure of the instruments either sampling or recording in the mobile van may disturb the ambient air quality survey.

On the other hand multiple nos. of survey stations can be carried out at the same cost as required for mobile monitoring system by high volume sampling technique with more man power. Hence it is felt that generally ambient air quality surveys should be carried out with high volume sampler techniques and specialised survey techniques and mobile monitoring should be used in the case of obtaining data for legal proceedings i.e. if any industry is required to be prosecuted for excessive emmission of particular pollutant, then this mobile van should be used. Thus instead of having recording techniques for common urban pollutants like SO_2, NO_x, particulates, etc. the mobile van should have analytical facilities for uncommon pollutants like chlorine, hydrogen sulphide, ammonia, carbon disulphide, carbon monoxide, hydro carbons etc. Instead of continuous monitoring mobile vans, more attention needs to be given to the instrumentation based on "battery operated" techniques which will solve the problem of carrying out surveys in absence of electricity for land use planning. The matter has been discussed in detail because there may be increasing trend to have mobile monitoring system for ambient air quality survey in order to compete with the latest available techniques in air monitoring systems which will be expensive in the long run.

It is felt that a test for odour should also be introduced both qualitatively and quantitatively for ambient air quality surveys. Similarly qualitative and quantitative test for 'visibility' should be introduced. Conditions like smoke, smog, mist, fog etc. which are common causes of discomfort in residential areas, and which arise either due to temperature inversion conditions or local pollution are often not reflected in present ambient air quality surveys. As smoke, fog, mist, smog etc. have significant effect on visibility, the measurement of visibility will be very useful to interpret ambient air quality data.

As the Board constituted under Central Water (Prevention and Control of Pollution) Act, 1974, will also be the Central Board to prevent and control or abate air pollution in the country, it will be administratively convenient and economical to adopt a uniform policy for settling up emission standards for small boilers/thermopacs (upto 10 MT of furnace oil or equivalent coal consumption per day) all over India. If the Central Board desires to abate SO_2 pollution from such small boilers, then it will be advisable to reduce sulphur content from bulk fuel and then to supply fuel with less sulphur content to such boilers which will be the most practical way to reduce sulphur dioxide emissions. It means preventive measures in the case of small fuel consumers should be taken at the fuel sulppliers' end rather than at consumers' end.

NEWS

I. AMMONIA GAS INJECTION FOR IMPROVING THE EFFICIENCY OF E.S.P.I.P. THERMAL POWER STATION OF DESU :

The flue gas conditioning, as a measure to improve the efficiency of electrostatic precipitator is rather uncommon in India. However, it is in successful operation at some of the power stations in U.S.A. and Australia.

Flue gas conditioning with H_2SO_4 injection had been tried at a few power stations in India but had not proved to be very successful. Recently encouraging results had been obtained at I.P. Power station of DESU at Delhi while trying flue gas conditioning with help of Ammonia, it is seen that with an ammonia injection rate of about 20 ppm, clear stacks (opacity 35-40%) could be obtained on a sustained basis.

II. EPA UNVEILS [PORTABLE DEVICE FOR MEASURING URBAN EXPOSURE TO CARBON MONOXIDE :

The U.S. Environmental Protection Agency has put on display a new portable device for measuring the urban American's exposure to Carbon monoxide (CO), and announced studies in Denver and Washington, D-C, where 1500 people will carry the instruments.

The portable mentioning device weighs about two pound and resembles a small portable radio carried by a shoulder strap. Statistically selected participants in the two cities will each carry the monitor for a day and record their activities in a diary. Computers inside the instruments will record the CO levels that each persons experiences.

Dr. Courtney Riordan, Acting EPA Assistant Administrator for Research and Development, called the devices "an excellent application of microtechnology to our every day lives. The studies will attach EPA the opportunity to assess health risks associated with carbon monoxide as well as evaluate the effectiveness of fixed site monitors as a reliable tool for estimating average exposures" he added.

III. ACID RAIN BENEFICIAL TO CROPS :

According to an item in Agrichemical Age, the very substance that figure in the acid rain-debate between Northeastern U.S. and Canada are providing sustenance for crops in India. Ali Tabatabai, ISU extension research agronomist, reports that corn and Soybeam readily utilize sulfur, nitorgen and other elements that are deposited in the form of acids and salts. The crops are especially dependent on sulfur because of the tendency toward sulfur-deficiency in many Iowa's soils. Tabatabai is also analyzing rain samples for phosphorus, calcium, magnesium, sodium and potassium, all of which would be benefical to crops if present in rain, to any appreciable extent.

IV. CLIMATE CHANGES DUE TO CO_2:

There is growing theoretical evidence that significant changes in the global climate can be expected as a result of known systematic increases in the CO_2 content of the atmosphere. Although there is no generally accepted observable evidence yet that climate is already shifting as a result of past CO_2 increases, the possible socio-economic consequences for the future are nevertheless already of urgent concern to many national and international political bodies. Since the presumed source of increased CO_2 is the accurated burning of fossil fuels, solutions to the problem may in part be preventive on the one hand, and ameliorative and adaptive on the other. Underlying the entire problem of improving estimates of risk are a series of scientific, technological and methodological uncertainties.

Recently monitoring measurements of atmospheric CO_2 clearly indicate an 8 percent increase over a 25 year period. The present level is about 340 ppm. It is estimated that the level in the mid 19th century was about 290 ppm and that by the middle of the next century a doubling to about 600 ppm will have occurred. Such estimates are based on uncertain long range projection of fossil fuel consumption and an assumption that the oceans will absorb about one half the emitted carbon.

There is controversy over the roles of the biosphene as both a source and a sink for carbon, reflecting considerable uncertainty about the entire biogeochemical cycle involving not only carbon, but nutrients (N, P, S etc) as well.

V. NBS TO PATENT NEW PROCESS TO REMOVE SO_2 AND NO_x FROM INDUSTRIAL GAS STREAMS :

Researchers at the Commerce Department's National Bureau of Standards (NBS) of USA are patenting an idea for a promising new chemical process that could be the basis for an improved method of removing sulfur dioxide as the flue gas from fossil fuel power plants.

What NBS Chemists Richard I. Martinez and John. T. Herron have proposed in a somewhat complicated mechanism for a series of chemical reactions that explain the results they and other researchers have observed in experiments with SO_2 and other gases.

At present, the popular method in the United States for removing SO_2 from exhaust gases is to circulate the gas through a slurry of powdered limestone suspended in water (a process called "Scrubbing"). The process can become messy and the equipment tends to get plugged up and caked with residue. Moreover, the end product is a precipitate, calcium sulphate, which has some minor commercial uses but usually winds up being buried in water-tight industrial waste sites.

The reaction chain proposed by Martinez and Herron, on the other hand, involves only gases, which suggests a way to avoide the plumbing problems caused by slurries. In addition, the SO_2 and NO_x are converted to sulfuric acid (H_2SO_4) and nitric acid (HNO_3) mists, both of which can be readily removed with existing methods and converted (by injecting ammonia, NH_3) to solid ammonium nitrates and sulfates, which are basic components of commercial fertilizers. The newly proposed reaction chain also produce some term of a combustible, sulfur and nitrogen free hydrocarbon (such as acetone) which would be commercially useful or atleast easily destroyed. As visualized by Martinez and Herron, the process would involve no complicated equipment or catalysts, would be unaffected by particles and other gases, and would not require critical temperature control.

Martinez and Herron base their conclusions on a series of experiments they and others have conducted, and on some theoretical work on the complex chemical mechanisms involved in the photochemical formation of Smog-research that includes the kinetics of oxidation reactions. In particular they noted that some have to fore incompletely understood experiments involving SO_2, Ozone, and various alkene compounds could be neatly explained by the sulfur compounds reacting with a group of short lives compounds known as *Criegee Intermediates*. These are highly reactive species ("dioxymethylene diradicals"), that form briefly as intermediate steps in a string of reactions between ozone and various olefine such a prophylene and ethylone. The reaction scheme, as they propose it, would require the addition of ozone, a suitable olefine such as propylene, and water vapour to the gas stream containing the SO_2. The olefine and ozone react to form the criegee intermediate, which in turn reacts with the sulfur dioxide and water vapor to produce sulphuric acid most and a ketene. The mist can be removed by presently available techniques. The Ketene can be removed and easily destroyed. Nitrogen oxides can also be removed in a similar manner.