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Original Research Paper

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EFFECTS OF TRAFFIC-RELATED AIR POLLUTION ON COGNITIVE FUNCTION AND ENVIRONMENTAL AWARENESS OF ADOLESCENTS

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ABSTRACT Air pollution has become a global public health concern. Common sources of outdoor air pollution are combustion of fossil fuels, and industrial and agricultural processes. For the last decade, literature on the detrimental impacts of air pollution on brain, cognition and behavior has increased immensely. There is increasing evidence of the hazards of air pollution on the central nervous system (CNS). Furthermore, air pollution has recently been considered as a suspected neurodevelopmental toxicant. There is enough evidence that exposure to a range of largely traffic-related pollutants is associated with quantifiable impairment of brain development in the young and cognitive decline in the elderly. Since there is insufficient evidence in case of adolescents, the present study has been undertaken to explore the adverse effects of traffic related air pollution on cognitive functioning and environmental awareness of adolescents belonging to the age group of 16 to 18 years. Samples have been selected from two higher secondary schools and the school selection has been done purposively on the basis of proximity of the school from the main road with heavy amount of traffic throughout the day. Four standardized tests on cognitive functioning and an Environmental awareness questionnaire have been administered and data have been analyzed by descriptive statistics, t-tests and one-way analysis of variance. The findings are coherent with earlier studies suggesting significant adverse influence of air pollution on cognitive functions as well as environmental awareness. Further environmental awareness has significant effect on memory, orientation and perceptuo-motor skills, which implies that it is necessary to increase awareness to control the adverse effects.

KEYWORDS : Air Pollution, Neural Development, Cognitive Function, Environmental Awareness

INTRODUCTION

Air pollution is probably one of the most serious environmental problems confronting our civilization today. Most often, it is caused by human activities such as mining, construction, transportation, industrial work, agriculture, smelting, etc. Air pollution can be defined as the presence of toxic chemicals or compounds (including those of biological origin) in the air, at levels that pose a health risk. Air pollution lowers the quality of the air and cause detrimental changes to the quality of life.

Air pollution has serious effects on the human health. Depending on the level of exposure and the type of pollutant inhaled, these effects can vary, ranging from simple symptoms like coughing and the irritation of the respiratory tract to acute conditions like asthma and chronic lung diseases. Skin problems and irritations can develop due to prolonged exposure to several air pollutants, and a variety of cancer forms may develop after inhaling air contaminants.

Air pollutants of major public health concern include PM (e.g., organic and elemental carbon [EC], metals and polycyclic aromatic hydrocarbons [PAHs]), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2). The cardiovascular and respiratory health effects of air pollution have been well documented, and there is increasing evidence of its hazards on the central nervous system (CNS). Furthermore, air pollution has recently been considered as a suspected neurodevelopmental toxicant. Neural development (e.g., proliferation, migration, differentiation, synaptogenesis, myelination, and apoptosis) extends from the embryonic period through adolescence. Therefore, this period is a critical developmental window for CNS development.

Evidence on the adverse CNS effects of air pollution in human and particularly animal studies has accumulated for over a decade. Inhaled pollutants deposit in the respiratory tract and can translocate to the CNS via the olfactory epithelium, via the blood brain barrier or via the sensory afferents found in the gastrointestinal tract. The potential cellular mechanisms identified as responsible for CNS damage are neuro-inflammation, oxidative stress, glial activation, and white matter injury. A better understanding of the specific components of air pollution responsible for CNS damage and the molecular mechanisms involved in humans still needs further research.

There is enough evidence that exposure to a range of largely traffic-related pollutants is associated with quantifiable impairment of brain development in the young and cognitive decline in the elderly. Thus there is increasing evidence of the hazards of air pollution on the central nervous system (CNS).

Lilian Calderón-Garcidueñas, et al (2014) reported that millions of children in polluted cities were showing brain detrimental effects. Urban children exhibited more brain structural and volumetric abnormalities, systemic inflammation, olfactory, auditory, vestibular and cognitive deficits than the low-pollution controls. Neuro-inflammation and blood-brain-barrier (BBB) breakdown target the olfactory bulb, prefrontal cortex and brainstem, but are diffusely present throughout the brain. Cognitive effects of air pollution were substantial across all populations, and potentially clinically relevant as early evidence of evolving neurodegenerative changes. They observed that protecting children and teens from neural effects of air pollution should be of pressing importance for public health.

The complexity of the urban atmosphere makes it very difficult to establish a direct association of CNS effects with specific air pollutants in humans. However, depending on the pollutant component, doses, exposure protocol, age and gender, health status, etc., the detrimental effects range from endothelial dysfunction, breakdown of the blood-brain-barrier (BBB); (**Levesque et al., 2011**), neuroinflammation (**Fonken et al., 2011**), formation of free radicals and oxidative stress (**Guo et al., 2012**), dopaminergic neuronal damage, RNA and DNA damage, to the identification of early hallmarks of Alzheimer and Parkinson's diseases (**Brun et al., 2012**).

Although evidence is not yet conclusive and further research is needed, the latest epidemiological studies support the hypothesis that pre or postnatal exposure to ambient pollution, particularly polycyclic aromatic hydrocarbons, PM2.5, and nitrogen oxides has a negative impact on the neuropsychological development of children. **Sunyer, Mar Alvarez-Pedrerol, et al (2017)** assessed the role of the exposure to traffic- related air pollutants during walking commute to school on cognitive development of children and found that exposure to PM2.5 and BC from the commutes by foot was associated with a reduction in the growth of working memory.

Given these perspectives the present study was undertaken to explore the adverse effects of traffic related air pollution on cognitive function and environmental awareness of adolescents. **Cognitive function** includes attention, memory, perception, decision making, problem solving etc. Each cognitive function works to help an individual gather and process information. E**nvironmental awareness** means being aware of the natural environment and making choices that benefit--rather than hurt--the earth we all live on. In recent years, environmental awareness has gained increased attention in order to conserve the environmental resources and protect human beings from the harmful effects of different types of pollution. The following objectives were considered in the present study:

- To find out if there is any difference in cognitive functioning (memory, attention, perceptuo-motor acuity and negative self-thoughts) of adolescents due to traffic related air pollution.
- To find out if there is any difference in environmental awareness of adolescents due to traffic related air pollution.
- To find out if there is any influence of environmental awareness on cognitive function of these adolescents.

METHOD

Participants

The participants were selected from English medium higher secondary schools under West Bengal Board of Kolkata and its adjacent areas. 10 schools were chosen randomly from the list of schools available in the website. Then 2 schools were identified purposively to fulfill the objectives of the study - one school situated in proximity of main road with heavy traffic throughout the day and the other school far from main road with open space and greenery. Finally students of classes XI and XII were selected randomly from class register to become participants of the present investigation. The size of the sample was 100 (50 from each school and 25 from each class). The sample comprised of both males and females and most of them belonged to middle income group.

Materials

Set test (Isaacs and Akhtar, 1972; Jatana et al, 1991; Dubey and Verma, 1991) for measuring memory, **Special ten** (Kahn et al, 1960) consisting of 10 simple questions for assessing general information, **Nahar and Benson scale** (Nahar et al, 1970; Persgad and Verma, 1978) consisting of eight drawings for measuring the degree of perceptuo-motor acuity and **Personal Assessment Inventory** (Samuel E. Krug and James E. Laughlin, 1976) for examining negative self-thoughts were used to find out the overall cognitive functioning. **Environmental Awareness Ability Measure** (Praveen Kumar Jha, 2010) provided a composite score of awareness and sensitivity to the total environment and its allied problems.

Procedure

The participants were selected from two higher secondary schools and with the prior consent of the authority data were collected from the students. Four standardized tests on cognitive functioning and an Environmental awareness questionnaire were administered on them after explaining the purpose. The instructions of each test were read out carefully and the investigator helped them in case of any difficulty. After data collection the responses were scored according to the norms and tabulated for analysis in Microsoft excel. Descriptive statistics, t-tests and one-way analysis of variance were computed in SPSS-20.

RESULTS

Table 1: ***Descriptive statistics of the variables according to schools***

Variables	Schools (Level of Pollution)	Mean	Standard Deviation
Memory	Low	31.24	4.28
	High	21.40	8.11
Orientation	Low	8.54	.952
	High	3.38	2.906
Perceptuo-motor acuity	Low	25.14	5.32
	High	33.32	11.07
Negative self-thoughts	Low	12.04	3.40
	High	11.70	3.11
Environmental Awareness	Low	42.82	6.57
	High	26.34	8.51

Table 1 shows the descriptive statistics according to the location of the schools (low pollution area and high pollution area). It clearly indicates that the mean scores of memory, orientation, perceptuo-motor acuity and environmental awareness vary according to levels of air pollution. The means of memory, orientation and environmental awareness are higher for the participants of the school situated in low polluted area. In case of perceptuo-motor acuity, the mean for low polluted school is lower than that of high polluted because higher scores indicate more errors. The mean scores for negative self-thoughts for adolescent students of both the schools are more or less same.

Table 2: Representation of t-Test Values according to level of Air Pollution

Variables	t - values	Decision
Memory	7.581**	Significant at .01
Orientation	11.932**	Significant at .01
Perceptuo-motor acuity	4.706**	Significant at .01
Negative self-thoughts	.521	Not significant
Environmental Awareness	10.831**	Significant at .01

****P < .01**

Table 2 represents the t-test values and it is observed that all the differences are significant at .01.

Table 3: Summary table of One way ANOVA including Environmental Awareness as independent variable and cognitive functions as dependent variables

Cognitive Functions		Sum of Squares	df	Mean SquarE	F	Sig.
Memory	Between Groups	1353.991	2	676.996	12.644**	.000
	Within Groups	5193.769	97	53.544		
	Total	6547.760	99			
Orientation	Between Groups	359.471	2	179.735	22.809**	.000
	Within Groups	764.369	97	7.880		
	Total	1123.840	99			
Perceptuo-motor Acuity	Between Groups	636.685	2	318.343	3.659*	.029
	Within Groups	8439.025	97	87.000		
	Total	9075.710	99			
Negative Self-thoughts	Between Groups	30.310	2	15.155	1.448	.240
	Within Groups	1015.000	97	10.464		
	Total	1045.310	99			

****p < .01, *p < .05**

The summary table of ANOVA (table 3) suggests that the variances of cognitive functioning due to environmental awareness (3 levels of awareness – low, average and high) are significant at .01 for memory and orientation, and at .05 for perceptuo-motor acuity. No significant variance is observed in case of negative self-thoughts.

DISCUSSION

The results of the present study reveal that traffic related air pollution has significant effect on the performance of students in tests on memory, orientation and perceptuo-motor acuity. Another interesting finding of this study is that awareness regarding importance of environment and environmental problems is also high for the students in the school located in low polluted area. So the findings corroborate with the previous as well as recent researches that have investigated

the effect of air pollution on cognitive functioning. The results are consistent with a recent study by **Chen, Zhang, Xin Zhang (2017)**. They have studied the effects of contemporaneous and cumulative exposure to air pollution on cognitive performance based on a nationally representative survey in China. By merging a longitudinal sample at the individual level with local air-quality data according to the exact dates and counties of interviews, they found that contemporaneous and cumulative exposure to air pollution impedes both verbal and math scores of survey subjects. In another study by **Sunyer, Esnaola, Alvarez-Pedreol, Forns, Rivas, Lopez-Vincet (2015)** associations have been found between the exposure to traffic-related air pollution at school and/or home and cognitive development.

They have reported that exposure to PM2.5 and BC from the commutes by foot is associated with a reduction in the growth of working memory (an interquartile range increase in PM2.5 and BC concentrations decreased the annual growth of working memory by 5.4 (95% CI [-10.2, -0.6]) and 4.6 (95% CI [-9.0, -0.1]) points, respectively). The findings for NO2 have not been conclusive and none of the pollutants are associated with inattentiveness.

Allen, Klocke et al (2017) have stated that air pollution is associated with deficits in cognitive functions across a wide range of epidemiological studies, both with developmental and adult exposures. Studies in animal models are significantly more limited in number, with somewhat inconsistent findings to date for measures of learning, but show more consistent impairments for short term memory. It is assumed that the potential contributory mechanisms include oxidative stress/inflammation, altered levels of dopamine and/or glutamate and changes in synaptic plasticity/structure. **Angela Clifford, et al (2016)** have also observed weak but quantified relationships between various air pollutants and cognitive function through systematic review on the association between air pollution and performance on neurocognitive tests.

Lilian Calderón-Garcidueñas et al (2014) have reported that millions of children in polluted cities are showing brain detrimental effects. Urban children exhibit brain structural and volumetric abnormalities, systemic inflammation, olfactory, auditory, vestibular and cognitive deficits v low-pollution controls. Neuro-inflammation and blood-brain-barrier (BBB) breakdown target the olfactory bulb, prefrontal cortex and brainstem, but are diffusely present throughout the brain. Urban adolescent Apolipoprote in E4 carriers significantly accelerate Alzheimer pathology. Neuro cognitive effects of air pollution are substantial, apparent across all populations, and potentially clinically relevant as early evidence of evolving neurodegenerative changes. **Victor Lavy, Avraham Ebenstein, Sefi Roth (2012)** have found that while PM2.5 and CO levels are only weakly correlated with each other, both exhibit a robust negative relationship with test scores of cognitive functioning.

It is interesting to find out that environmental awareness has significant effect on memory, orientation and perceptuo-motor skills, which implies that it is necessary to increase awareness to control the adverse effects of traffic related pollution. We all know that environmental awareness is to understand the fragility of our environment and the importance of its protection. This study confirms the belief that it is necessary to make students understand the positive effects of environment on **health, sustainable development** and reducing **global warming. Environmental awareness will motivate the students to develop behaviours and enable them to protect themselves from the adverse effects of environmental pollution. In future they will be able to take measures to protect the environment through positive attitudes and appropriate decisions.**

CONCLUSION

The major finding of this study, that cognitive deficits occur due to traffic related air pollution, is coherent with the results of all other studies in this area. However, it should be mentioned that the sample of this study is quite small to draw any conclusive generalization. In view of the different indices of pollution and end-points measured, it is difficult to comment at this stage. But there is no doubt that vehicular pollution contributes to cognitive impairment. Thus this study implies that both governments and individuals should continue to reduce air pollution. More concerted efforts are necessary to increase environmental awareness among students from childhood to protect the environment and prevent cognitive decline. Further it is our responsibility to improve our knowledge and awareness regarding environment in order to promote positive behavior and attitude towards environment. An implication of this finding is that high pollution levels results in cognitive inefficiency of students that will ultimately lead to inefficient and possibly a less productive population for future.

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