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Salivary Antioxidant Potential and Oral Lesions in Thermal Power Plant Workers: A Cross-Sectional Study

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Abstract

Background: Air pollution affects the neurological, respiratory, cardiovascular, and other systems, posing serious health risks. Lead is a common industrial contaminant that damages tissues, including saliva, and induces oxidative stress. Thermal power plant workers are particularly vulnerable due to occupational exposure. Saliva, the first line of defense against oxidative stress, contains antioxidants such as glutathione peroxidase (GPX), superoxide dismutase (SOD), and total antioxidant capacity (TAC). This study aimed to evaluate salivary antioxidant potential and the prevalence of oral lesions among thermal power plant workers, and to assess the impact of occupational oxidative exposure.

Materials and Methods: Fifty-two individuals were included: twenty-six thermal power plant workers (Group I) and twenty-six controls (Group II). Saliva samples at 20%, 40%, 60%, 80%, and 100% concentrations were analyzed using the ferric reducing antioxidant power (FRAP) assay. Samples were stored at -20°C. Intraoral examinations recorded oral lesions.

Results: Across all concentrations, Group I's mean TAC values were consistently lower than Group II's, although the differences were not statistically significant ($p > 0.05$). Group I's TAC ranged from 1.52 to 3.07 at each concentration level, which was marginally lower than Group II's 2.29 to 3.37 range. Three of the 26 employees at the thermal power plant had oral lesions, whereas none in the control group did.

Conclusion: Thermal power plant workers exhibit lower salivary antioxidant levels, indicating a heightened risk of oxidative stress and related health issues.

Keywords: Air Pollution, Occupational Exposure, Environmental Toxicology, Oxidative Stress

Introduction

Human health can be seriously harmed by air pollution. The neurological, respiratory, cardiovascular, renal, gastrointestinal, pregnancy, and cell functions are all adversely affected. A person's health state is influenced by both environmental and occupational influences. Exposures at work and in the environment may be linked to symptoms of certain diseases [1]. A patient's environmental exposures may call for certain actions to reduce the risk of occupational diseases and avoid further adverse effects. One of the most significant environmental contaminants is lead, which is a global health concern [2-4]. Lead has been used extensively across industries, contaminating air, water, and food. As a result, lead levels in serum and saliva, as well as its

buildup in various bodily tissues, have significantly increased in recent years [5].

The characteristics of the dangers posed by the supplies and machinery used in regular operations make thermal power plants (TPPs) extremely dangerous places. Workers at TPP sites are exposed to heavy-duty rotating machinery, high voltages, poisonous chemicals, highly combustible materials, high-pressure, high-temperature steam systems, loud noises, and noxious smells, all of which can be extremely harmful to their health.12 Employees of thermal power plants have been found to suffer from a variety of illnesses. Bronchial asthma, chronic bronchitis, pneumonia, emphysema, TB, wheezing, lung cancer, stroke, chest pain, shortness of breath, cough, irregular heartbeat, leg and foot swelling, skin allergies, hypertension, anxiety, eye irritation, and exhaustion are among them. Due to systemic, environmental, and local factors, the oral mucosa can undergo pathological changes [6].

Antioxidants are crucial for preventing the formation of reactive oxygen species, such as O2, H2O2, and alkyl peroxyl radicals, as well as for repairing the damage they cause. The first line of defense against environmental influences is saliva, which contains a variety of protective mechanisms, including lactoferrin, histatins, lysozyme, secretory immunoglobulin A, and the enzymatic-protein defense system. Another defense mechanism of saliva is the salivary antioxidant system, which includes glutathione peroxidase (GPX), superoxide dismutase (SOD), uric acid, and (TAC). (1)

Recent research has highlighted the critical role of antioxidants and redox status in human health. Studies by various authors have explored this relationship in diverse populations and exposure scenarios. Ban T. Al-Souz and Wesal A. Al-Obaidi investigated the relationship between salivary antioxidants and dental caries among lead-acid battery workers, concluding that while dental caries was more prevalent, selected salivary antioxidants had little effect [7]. Similarly, Natividad Sebastià et al. examined the effect of low-dose ionizing radiation on the blood redox status of healthcare workers, finding that occupational exposure correlated with a redox imbalance [8]. Complementing these findings, a review by Ilaria Peluso and Anna Raguzzini on salivary and urinary Total Antioxidant Capacity (TAC) as biomarkers for oxidative stress highlighted how factors like diseases, diet, and lifestyle influence TAC levels, suggesting its utility as a diagnostic tool [9].

Building on this foundational work, this write-up will expand on evaluating total antioxidant capacity (TAC) levels in saliva and on assessing oral lesions in thermal power station workers.

Materials and Methods

This cross-sectional study involved 52 participants, divided into two groups: 26 who work in a thermal power plant (Group I) and 26 controls (Group II).

The inclusion criteria for the study are the age range of 20-50 years, and the study subjects must work in a thermal power plant.

Exclusion criteria for this study include people with systemic disorders, people who have used immunosuppressive drugs or oral sprays, people who have undergone chemotherapy or radiation therapy, smokers, alcoholics, and gas station workers.

The sample size was estimated using G Power software 3.1.9.4 by using the data derived from the study by Tonkaboni et al. [1] and was estimated as in t tests - Means: Two independent means (two groups) and their differences. A priori power analysis was conducted to compute the required sample size for a two-tailed test. The analysis used an effect size (d) of 4.2505028, a significance level (α) of 0.05, and a desired power (1-β) of 0.95. The allocation ratio (N2/N1) was set to 1, ensuring equal sample sizes in both groups. The analysis yielded a noncentrality parameter (δ) of 7.2056145 and a critical t-value of 2.756479 with 4 degrees of freedom. The required sample size for each group was calculated to be 26, resulting in a total of 52 participants. The actual power achieved with this configuration was 0.9778513, slightly exceeding the desired power and ensuring adequate sensitivity to detect the specified effect size.

Patients from both groups were examined for intraoral lesions after obtaining informed consent. Five milliliters of unstimulated whole saliva was collected and stored in a deep freezer at -20 degrees Celsius. Then the FRAP assay was conducted by preparing serial dilutions of each sample at 20, 40, 60, 80, and 100 percent concentration. After that, 2.5 milliliters of potassium ferricyanide and phosphate buffer were added to each sample. The next step is incubating all the samples at 50 degrees Celsius. Following the incubation period, 2.5 milliliters of trichloroacetic acid were added, and the mixture was centrifuged for ten minutes at 3000 rpm. 0.5 ml of ferric chloride was added to 2.5 ml of this solution after it had been combined with 2.5 ml of distilled water. A UV-visible spectrometer was then used to measure absorbance at 700 nm after the mixture was incubated in the dark for 30 minutes [10] (Fig. 1).

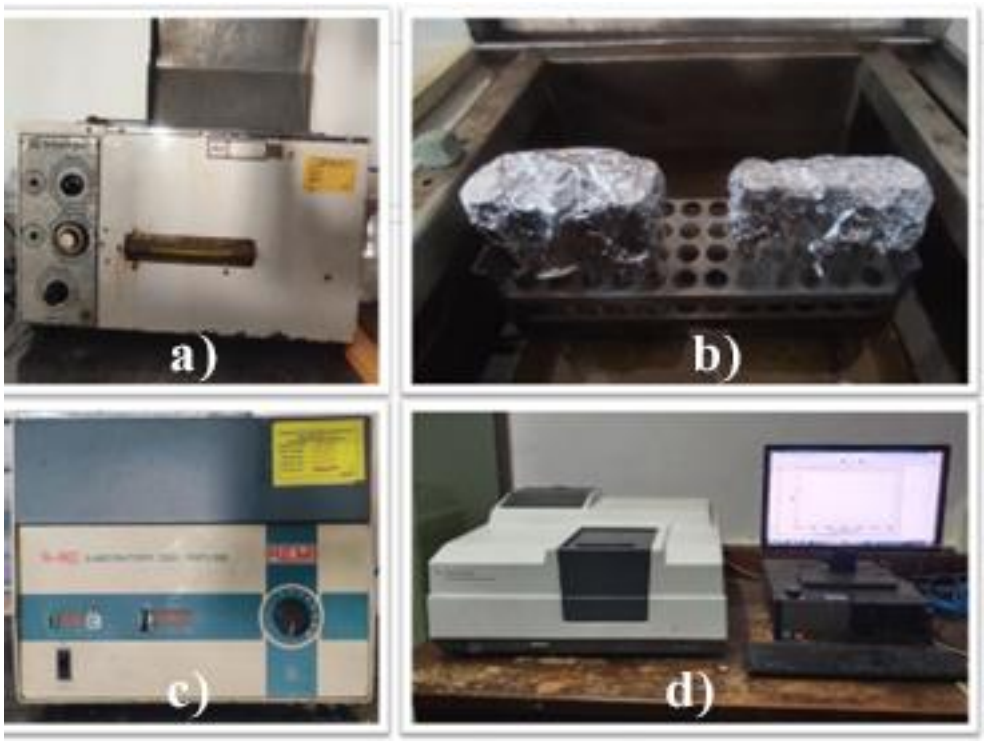

Fig. 1. a) Incubator b) Water bath c) Centrifuger d) Spectrophotometer

Results

Table 1 presents the demographic details of the study participants by age. The control group consisted of 26 individuals with a mean age of 32.20 years and a standard deviation of 11.23, suggesting greater age variation within this group. In comparison, the sample group comprised 26 individuals, with a higher mean age of 36.89 years and a lower standard deviation of 8.67, suggesting that the ages in this group were more closely clustered around the mean. This difference in mean age may imply a slightly older population in the sample than in the control, which could influence the outcomes being studied. The narrower age dispersion in the sample group indicates greater age homogeneity. Further statistical analysis would be needed to determine whether the difference in mean age between the groups is statistically significant and whether it affects the study results.

Table 1. Reprsents the demographic details of the study samples

Age (n)	Mean	Standard deviation
Control – 26	32.20	11.23
Sample - 26	36.89	8.67

Table 2 presents a comparison between the control and sample groups at 5 saliva concentrations (20%, 40%, 60%, 80%, and 100%) to assess mean values and variability. At 20% concentration, the control group showed a slightly higher mean (2.46 ± 0.633) than the sample group (2.38 ± 0.460), with a non-significant p-value (0.83), indicating no statistically meaningful difference. This trend continued at 40%, where the control group (2.37 ± 0.710) again exceeded the sample group (1.87 ± 0.307), though the difference remained statistically insignificant (p = 0.34). Similarly, at 60% and 80%, while the control group consistently exhibited higher mean values than the sample group, the differences did not reach statistical significance (p = 0.26 and 0.12, respectively). At 100% concentration, both groups showed elevated mean values: control (3.37 ± 0.847) and sample (3.07 ± 0.784); however, the p-value (0.76) again indicated no significant difference. Overall, across all concentrations, although mean values varied, none of the comparisons yielded statistically significant differences, suggesting similar performance in both groups under these experimental conditions.

Table 2. Represents the difference between the study groups at various concentrations of saliva measured in

Groups	N	Concentration	Mean	Standard deviation	95% confidence interval		Sig
					Lower	Upper	
Control	26	20	2.46	.633	2.20	2.72	0.83
Sample	26		2.38	.460	2.19	2.57	
Control	26	40	2.37	.710	2.08	2.66	0.34
Sample	26		1.87	.307	1.75	1.99	

Control	26	60	2.32	.636	2.06	2.58	0.26
Sample	26		1.52	1.081	1.10	1.94	
Control	26	80	2.29	.479	2.10	2.48	0.12
Sample	26		1.98	.258	1.88	2.08	
Control	26	100	3.37	.8470	3.03	3.71	0.76
Sample	26		3.07	.7842	2.75	3.39	

Table 3 displays the distribution of oral lesions between the control and sample groups. In the control group, none of the 26 participants had oral lesions, and all were lesion-free. Conversely, in the sample group, 3 participants exhibited oral lesions, and 23 were lesion-free. Overall, among the 52 participants, only 3 had aphthous ulcers, while the remaining 49 had none. Fisher's Exact Test was used to assess the statistical significance of this difference due to the small cell counts. The p-value obtained was 0.235, indicating that the observed difference in oral lesion occurrence between the control and sample groups is not statistically significant. This suggests that although oral lesions were exclusively seen in the sample group, the difference may be due to chance and does not imply a meaningful association between group type and lesion presence within the scope of this study.

Table 3. Represents the Oral Lesions Presence or Absence among the Study Group

Groups	Present	Absent	Total	Fishers exact P-value
Control	0	26	26	0.235
Sample	3	23	26	
Total	3	49	52	

Discussion

Saliva is considered the first line of defense in the oral cavity, and its antioxidant components, such as uric acid, are rapidly consumed in response to an oxidative challenge. The role of occupational exposure to pollutants in inducing oxidative stress is well documented in the literature. However, the specific impact on salivary antioxidant status varies depending on the type of exposure and the study methodology. The present study investigated the salivary total antioxidant capacity (TAC) and the prevalence of oral lesions in thermal power plant workers, a population potentially exposed to industrial air pollutants. Our results indicated a consistent, though not statistically significant, reduction in mean salivary TAC values among the thermal power plant workers compared to the control group. Furthermore, oral lesions were observed. These findings, while limited by sample size, suggest a trend towards a compromised antioxidant defense system and potential early signs of oxidative damage in this occupational group.

Our finding of a decreased TAC trend in thermal power plant workers aligns with the general principle that chronic exposure to environmental toxins depletes the body's antioxidant reserves. This is supported by studies on other occupational groups. For instance, a similar study by Greabu et al. found a statistically significant decrease in salivary TAC in non-ferrous metal mine workers, suggesting that long-term exposure to mine dust can lead to a measurable reduction in salivary antioxidant defense [11]. The discrepancy in statistical significance between our study and Greabu et al.'s may be attributed to our smaller sample size (26 workers vs. 30 mine workers) and to potentially different types or levels of exposure. A larger sample size, as recommended in our limitations, would be essential to validate the observed trend and potentially achieve statistical significance.

Further comparison of our results with those from other studies using different samples and biomarkers is crucial for a comprehensive understanding. A study by Sakhvidi et al., for example, evaluated the effects of respiratory exposure to benzene on plasma TAC in oil company workers and reported a notable decrease in TAC in the exposed group [12]. While this study measured plasma rather than salivary TAC, it provides important corroboration for the concept that occupational exposure to airborne chemicals negatively impacts the body's overall antioxidant capacity. This supports the biological plausibility of our findings. Similarly, Farokhzad et al. demonstrated a significant increase in malondialdehyde (MDA), a marker of lipid peroxidation, in the saliva of workers exposed to crystalline silica dust [13]. The significant increase in a pro-oxidant marker, MDA, in their study, in contrast to our non-significant TAC results, could indicate that different biomarkers may have varying sensitivities to different types of occupational stressors. It also reinforces the suitability of saliva as a non-invasive medium for assessing oxidative stress.

Interestingly, our findings contrast with some studies that have reported increased antioxidant status in response to occupational exposure. For example, Han et

al. observed an increase in serum total antioxidant status (TAS) and glutathione peroxidase (GPx) in asymptomatic shipyard welders [14]. This apparent contradiction highlights the complexity of the body's response to oxidative stress. The systemic response (as measured in serum) may involves an upregulation of antioxidant enzymes and defenses to counteract the stress, while the local response in saliva, which is in direct contact with the inhaled pollutants, shows a depletion or consumption of antioxidant capacity. Therefore, a decrease in salivary TAC may reflect the immediate local response to pollutants, rather than the body's overall compensatory response.

The observation of aphthous ulcers in three thermal power plant workers, while not statistically significant, is another point of concern. This finding suggests a potential link between occupational exposure and oral health, possibly mediated by oxidative stress. Oxidative stress can damage cellular components, including DNA, proteins, and lipids, leading to tissue inflammation and pathological changes. The presence of lesions in the exposed group and their absence in the control group is a preliminary signal warranting further investigation.

A larger cohort would increase the statistical power to detect meaningful differences in TAC and oral lesion prevalence. A longitudinal study, following workers over time, would provide a clearer picture of how chronic exposure affects antioxidant status and whether these changes precede the development of oral lesions. Future research should also consider measuring specific salivary antioxidants, such as uric acid, glutathione peroxidase (GPx), and superoxide dismutase (SOD), to provide a more detailed profile of the antioxidant defense system.

Our study, despite its limitations, provides preliminary evidence that thermal power plant workers may be susceptible to oxidative stress, as indicated by a trend of reduced salivary TAC and an increased prevalence of oral lesions. These findings, when viewed in the context of a growing body of literature on occupational health and oxidative stress, underscore the potential of salivary TAC as a non-invasive, accessible biomarker for monitoring the health of industrial workers. Future research with more robust methodologies is needed to confirm these findings and better to understand the long-term health implications for this vulnerable population.

To mitigate the negative impacts on total antioxidant capacity (TAC), various interventions should be considered, including lifestyle modifications, workplace health promotion programs, and antioxidant supplementation. Emphasis should be placed on improving sleep quality, encouraging regular physical activity, increasing intake of antioxidant-rich foods, and exploring the potential benefits of targeted antioxidant therapy. The present study has limitations, including a relatively small sample size that may limit the generalizability of the findings, and a cross-sectional study design that precludes the establishment of causal relationships.

Conclusion

The current study found that thermal power plant personnel had a slightly higher prevalence of oral lesions and a tendency toward lower salivary total antioxidant capacity (TAC) than healthy controls. These results suggest a potential link between early oxidative imbalance and occupational exposure, although the findings are not statistically significant. An effective non-invasive biomarker for evaluating oxidative stress in industrial workers may be salivary TAC. To confirm these results and better understand the causal link between occupational exposure and salivary antioxidant capacity, more research with larger sample sizes and longitudinal follow-up is required.

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Conflict of interest

None declared.

Funding

None.

Ethical Considerations

A written informed consent form was signed by each participant before their involvement in the study. The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Code of Ethics

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of K.S.R. Institute of Dental Science and Research (IEC Proposal No.: IEC-PG/JUN/2024/169).

Authors' Contributions

Anbirselvam Arunmozhi: Conceptualization and

design of the study, data collection, and data analysis; Sundersingh Sam Ponraj Davidson: Drafting of the manuscript; Balasubramanian Senthil Kumar: Supervision and overall guidance throughout the study; Suman Jhansi Lakshmi and Selvam Keerthana: Review and editing of the manuscript. All authors read and approved the final manuscript.

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