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Assessment of air quality index of Jaipur city (Rajasthan) India

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Abstract

The major cause of bronchitis and lung infections is air pollution. The PM2.5, PM10, CO_2, CO, NOx, and HC pollutants are included in the air quality index, which measures the total amount of air pollution in the atmosphere. The AQI should be keeping pollution levels within acceptable ranges, and a higher reading meant more pollution. Twenty Indian cities rank among the top fifty most polluted cities in the world, with an AQI of greater than 266. The need to consider air quality index and put regulations in place to lower it is worrying. This study is presented the various air pollution contaminations and AQI at three different positions in Jaipur Rajasthan. It is found that the Police Commissionerate found more polluted than the Adarsh Nagar and Shashtri Nagar Jaipur.

Keywords: Air pollution; Air pollution index; PM2.5; PM10; Ammonia; Carbon monoxide

1. Introduction

Input of dangerous compounds for people and other living things into the environment is referred to as pollution. Pollutants are dangerous substances—solid, liquid, or gas—that are created in greater quantities than normal and lower the quality of our environment. By contaminating the water we drink, the air we breathe, and the soil where plants grow, human activities have a negative impact on the ecosystem. Even if the industrial revolution greatly advanced technology, society, and a variety of services, it also brought about the generation of enormous amounts of air pollutants that are damaging to human health.

Using monitoring networks created to measure and record air pollutant concentrations at various places thought to reflect population exposure to these pollutants, many cities throughout the world regularly examine the quality of the air. According to recent research, proposed pollutant level standards cannot be viewed as cutoff points below which no detrimental effects can be anticipated. Therefore, unless properly defined, a crude comparison of observed values to standards may be misleading.

Governments now offer the general public with information on air quality in a variety of formats, including yearly reports, environmental evaluations, and site- or topic-specific analyses and reports. These often only reach a small audience and need the appropriate time, attention, and background to understand their contents.

The daily air quality is reported using the AQI index. An growing percentage of the populace is anticipated to endure more severe unfavourable health consequences as the AQI rises. There are several, inconsistent air quality indicators used by various nations. Additionally, various nations refer to their indexes by different names, such as the Air Pollution Index and the Pollutant Standards Index (PSI) [1]. In both industrialized and developing nations, air pollution has been persistently related to significant burdens of ill health [2,3].

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According to a research based on 2016 statistics, 13 cities was listed in to of the most polluted 20 cities of the with the worst yearly levels of air pollution are in India, and at least 140 million people there breathe air that is 10 times or more over the WHO acceptable limit. Industrial pollution accounts for 51% of pollution, followed by automobile pollution (27%), agricultural burning (17%), and miscellaneous causes (5%)[4, 5].

India's air pollution is a severe health risk; in 2019, 21 Indian cities listed in to most polluted cities in the world's 30 most polluted cities list [6]. It will be implemented in 102 cities where air quality is deemed to be below the national ambient air quality standards [7].

According to the World Health Organization (WHO), indoor and outdoor air pollution in cities is a serious public health concern that contributes to more than 2 million preventable deaths annually (WHO, 2006) [8]. However, the effects of air pollution on public health are quantified in terms of lost productivity, missed chances for education and other human development, as well as illnesses and deaths (UN, 2001)[9].

According to the Clean Air Act of 1970, lead, sulphur dioxide, carbon monoxide, particulates, volatile hydrocarbons, and photochemical oxidants are the worst health risks. Without a question, these pollutants have the potential to endanger both human health and the environment, as well as cause serious property damage. Particle pollution and ground level ozone are the two pollutants that pose the greatest harm to human health, according to a number of academics, ranking above the other six pollutants [10]. The epidemiological and laboratory investigations also showed that ambient air pollutants, such as PM, O_3, SO_2, and NO_2, were a factor in bronchitis, emphysema, and asthma, among other respiratory conditions (Ling et al, 2012)[11, 12].

The AQI and air pollution have an impact on human health, and several studies have been conducted and presented in various formats. The majority of air pollutants negatively impact human health in a variety of ways, including: eye irritation caused by NOx, O_3, PAN, particulates; nose and throat irritation caused by SO2, NOx, etc.; odour nuisance caused by H_2S, SO_2, NO_2, and hydrocarbons; and irritation of the respiratory tract caused by SOx, NOx, CO, and O_3. Bronchitis and asthma are brought on by the high levels of SO2, NO2, and SPM; the blood's ability to transport oxygen is decreased by the high levels of CO and NO; Lead and Mercury poisoning and kidney and liver damage are both caused by heavy metal concentrations that are too high[13-23].

The air quality assessment of Jaipur city (India) based on PM2.5, PM10, NO_2, NH_3, SO_2, CO, Ozone and their cumulative index called air quality index (AQI) is assessed and presented in this study. These data were collected from January 2022 to December 2022 (12 months) and evaluated carefully. The study is most beneficial to the researchers, scientist and the officials who are working in this field.

2. Material and methods

2.1. Air Quality Index (AQI)

Table 1 AQI level and measure health effect [25]

S. No.	AQI Level	Category of Level	Colour Coding	Measure Health Impact
1	0-50	Good	Green	Minimum Impact
2	50-100	Satisfactory	Light Green	It may cause minor breathing difficulties for sensitive people
3	101-200	moderately polluted	Yellow	It may cause breathing difficulties for sensitive people or children / old persons with lung disease like asthma, and discomfort with heart disease
4	201-300	Poor	Orange	It may cause prolonged exposure and discomfort to the people with heart disease
5	301-400	Very poor	Red	It may cause respiratory illness on prolonged exposure with lung and heart disease.
6	401-500	Severe	Maroon	It may cause respiratory issues in healthy peoples and serious health issue in already sick people and difficulty may be experienced during physical activities.

The EPA as well as Indian standard calculate the AQI for using five measure air pollutants, these are given as: Particle pollution/Particulate matters (PM2.5/PM10), Carbon dioxide (CO_2), Sulfur dioxide (SO_2), Nitrogen dioxide (NO2), and ground level ozone (O_3). As concerns with AQI, the higher value of it indicates the greater pollution. The AQI index categorised into six major groups as shown in table 1 with causes of measure health effect.

Any air quality index's fundamental goal is to use an appropriate aggregation process to convert the observed concentrations of each air pollutant into a single numerical index. Every index should, in theory, reflect both the measured and widely perceived ambient air quality for the time period it covers[24].

2.2. Mathematical Formulations of AQI

Kyrkilis et al. [26] presented an aggregate AQI in 2007. The five criterion pollutants (CO, SO_2, NO_2, O_3, and PM10) that make up the index are combined impacts, taking into consideration European requirements. This approach was used to evaluate the air quality at each monitoring station located around the city of Athens, Greece. The AQI system, created by Swamee and Tyagi [27], serves as the foundation for the indexing system. Equation (1) is used to calculate an aggregate AQI and is displayed below:

$$I = [\sum_{i=1}^{n}(AQI)^p]^{1/p} \ldots\ldots\ldots\ldots\ldots (1)$$

Where, I is the aggregate AQI, AQI_i=the sub-index for ith pollutant, and p=a constant. According to eqn. (1), when $p=\infty$ the index I is equal to the max AQI of a single pollutant, regardless of the rest of the pollutants' AQI value.

This method of computation is similar to how the EPA determines the total AQI, except it overestimates the amount of air pollution. The overall index (I), on the other hand, is equal to the total of all AQI indices when p is equal to 1, at the other extreme. To substantiate this assertion, the choice of the ideal value for p is still up for debate. The ratio of pollutant concentration q to standard concentration qs, as stated in equation (2), is used to express the sub-indices.

$$AQI_i = AQI_s\left(\frac{q}{q_s}\right) \ldots\ldots\ldots\ldots\ldots (2)$$

Where, AQI_i=Sub-index of ith pollutant, and AQIs= a scaling coefficient equal to 500 [27].

3. Results and discussion

3.1. Data Collection

As simple as checking the weather is monitoring the local air quality. On the Internet, in your local media, and on a number of state and local telephone hotlines, you may find the most recent AQI readings. The AIRNow website was created by EPA and its federal, tribal, state, and local partners to give the public simple access to data on the nation's air quality. For over 300 cities around the United States, you may discover daily AQI forecasts and current AQI conditions at www.airnow.gov, along with connections to more in-depth state and municipal air quality Web sites. The maps that AIRNow's reports present allow you to rapidly evaluate whether the local air quality is harmful.

The data of Adarsh Nagar, Police Commissionerate and Shastri nagar Jaipur were collected from the CPCB website, Government of India from January to December 2022 [28].

3.2. Particulate matters (PM2.5) of the observation area

The aerodynamic diameter of PM particles, measured in micrometres (μm), is used to classify them. The 10 μm diameter or PM10 particles, sometimes referred to as "coarse" particles, are regularly measured by air quality monitoring equipment in France and countries like India. PM2.5 or fine particles, are those having a diameter of less than 2.5 μm. Additionally there has been interest in so-called "ultra-fine" particles, or PM0.1, which have a diameter of 0.1 μm (or 100 nm). The diameter of the particulate matter is the crucial factor because they penetrate the bronchopulmonary system and into the body. The tiniest particles, measuring at least 2.5 micrometres in diameter, are referred to as "fine" particles. Only an electron microscope is able to identify these tiny particles. Motor cars, power plants, domestic wood burning, forest fires, agricultural burning, various industrial activities, and other combustion processes are significant producers of fine particles.

The PM2.5 is observed for three places Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur from January to December 2022 (One Year) and it is found that the fine particulate matter is higher between January and February, April

and May October and December and found lowest in rainy season of July and August. The place of Police Commissionerate is observed more polluted than other two places it is because of higher traffic and vehicle pollution.

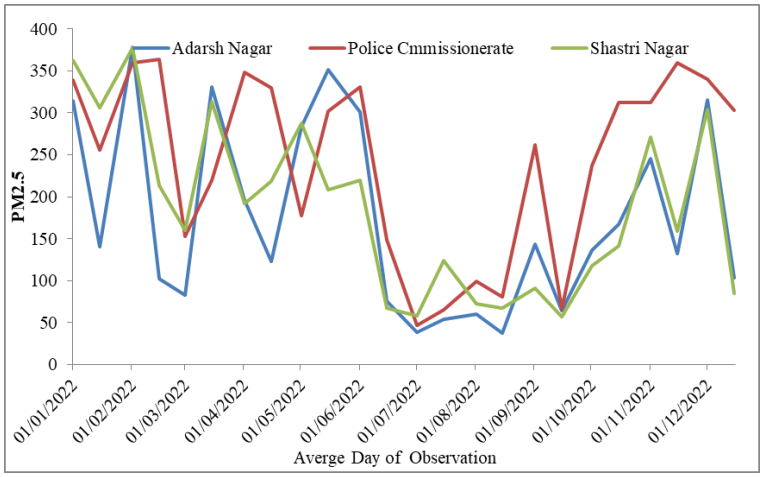

Figure 1 PM2.5 for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

3.3. Particulate matters (PM10) of the observation area

"Coarse" particles are those with a diameter of 2.5 to 10 micrometres. Crushing and grinding processes as well as road dust stirred up by moving cars are sources of coarse particles. The air quality limitation guideline is presented in table 2.

Table 2 Air quality limitation guideline [29]

S.No.	Duration	WHO Guidelines				
		For M2.5 µg/m3	For PM10 µg/m3	O3, µg/m3	NO2, µg/m3	SO2, µg/m3
1	Annual Mean	5	15	60 (8 Hr mean Peak Season)	10	
2	24-Hour Mean	15	45	100 (8 Hr daily Maximum)	25	40

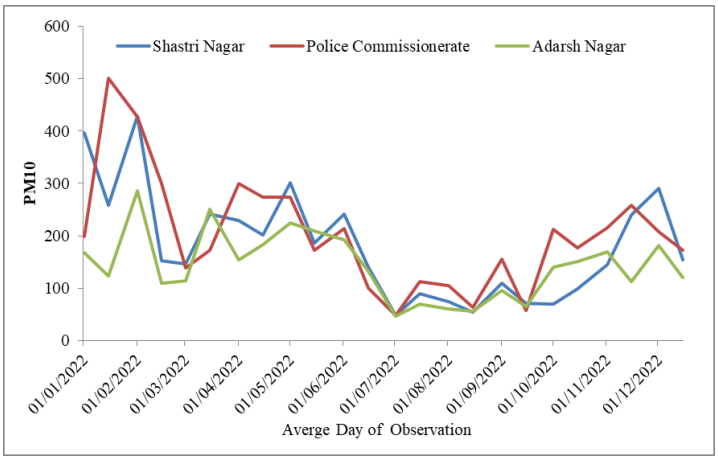

Figure 2 PM10 for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

The Figure 2 shows the concentration of PM10 at various places in Jaipur city and is observed for three places Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur from January to December 2022 (One Year) and it is assessed that the coarse particulate matter (PM10) is highest between January to February 2022. On the other hand, April, May

October and December found slightly higher. For whole the year 2022, Police Commissionerate is observed higher polluted than other two places.

3.4. Nitrogen-di-oxide of the observation area

The Figure 3 shows the concentration of NO_2 at various places in Jaipur city and is observed for three places Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur from January to December 2022 (One Year) and it is assessed that the nitrogen-di-oxide is highest between February to March 2022. On the other hand, it is observed that the value of nitrogen-di-oxide found higher throughout the year except it is slightly lower in the starting of June 2022 from Shastri Nagar and between October to November from Adarsh Nagr. TheNO2 of Adarsh Nagar is laying between the Police Commissionerate and Shastri nagar most of the time.

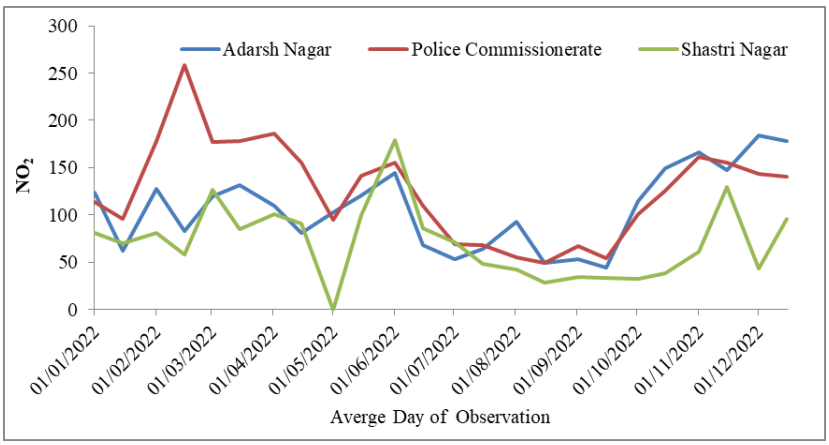

Figure 3 NO_2 for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

3.5. Ammonia (NH_3) of the observation area

The one year data of ammonia availability in the atmosphere of three places Adarsh Nagar, Police Commissionerate and Shastri Nagar in Jaipur is presented in Figure 4. It is observed that the highest ammonia is found at February 01, 2022 in Police Commissionerate and lowest on January 01, and from February 15 to March 01, 2022. In similar way the lowest NH_3 is also found Shastri Nagar on May 01, 2022. The concentration of Ammonia is found approximately average.

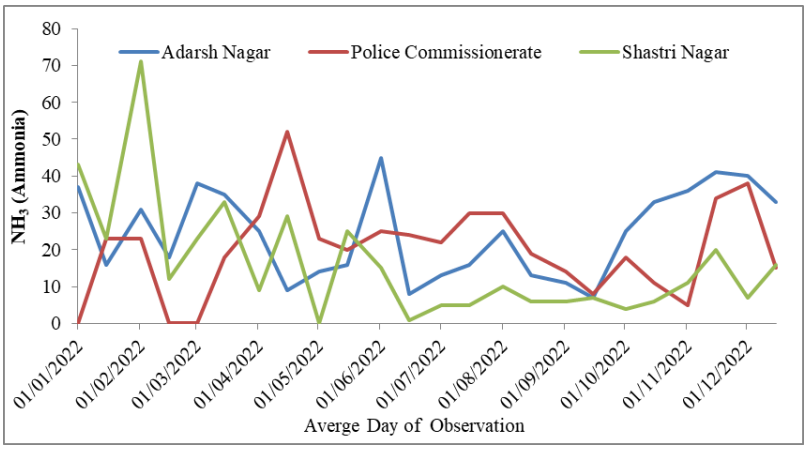

Figure 4 NH_3 for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

Ammonia enters the body by inhaling, ingesting, or contact with the skin, where it interacts with water to form ammonium hydroxide. This substance is extremely corrosive and harms bodily cells upon touch. Ammonia corrodes things. The method, dose, and length of exposure all affect how bad the health impacts will be. High levels of ammonia in the air can cause rapid eye, nose, throat, and respiratory tract burning as well as blindness, lung damage, or even death. Lower amounts of the substance might irritate the nose, throat, and induce coughing.

3.6. Sulphur-di-oxide (SO_2) of the observation area

When sulfur-containing fuels like coal and oil are burnt, sulphur dioxide, a colourless, reactive gas, is created. Sulfur dioxide concentrations are often higher in areas close to sizable industrial complexes. Power stations, refineries, and commercial boilers are significant suppliers.

Sulfur dioxide exposure for a long period of time may result in respiratory problems, sickness, and an aggravation of asthma. Sulfur dioxide is especially dangerous to those who have asthma. Children and older individuals may also be vulnerable to these consequences, as well as those who have other chronic lung or cardiovascular conditions.

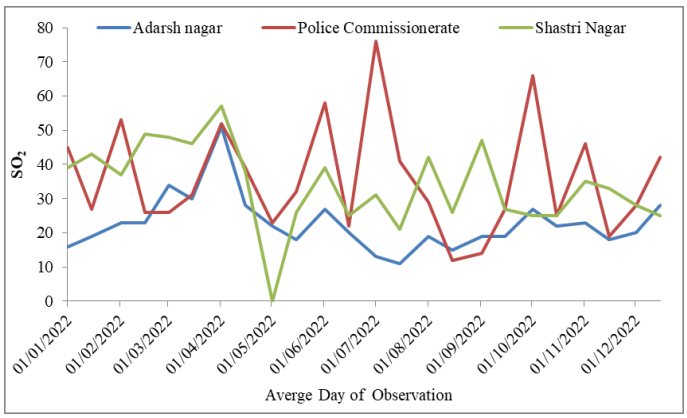

Figure 5 SO_2 for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

Figure 5 shows the concentration of SO_2 in environment of three and it is observed that the highest value of SO_2 is found at Adarsh Nagar, Police Commissionerate and Shastri Nagar is 51, 76 and 49 respectively. The lowest value of SO_2 is observed these three places 11 (in July) of Adarsh Nagar, 14 (in September) of Police Commissionerate and 21 (in July) of Shastri Nagar. The higher value of SO_2 is dangerous for human health. The maximum prescribed limit value of SO_2 by WHO are 40 in 24 hours and it is observed that the maximum values are higher than the limiting value in particular days/months.

3.7. Carbon Monoxide (CO) of the observation area

A colourless, odourless gas, carbon monoxide has neither. It develops as a result of incomplete combustion of the carbon in fuels. Approximately 75% of the nation's carbon monoxide emissions are caused by vehicles, and that percentage can reach 95% in urban areas. Other sources include natural sources like wildfires and industrial operations that burn fuel. Because low temperatures make combustion less complete and generate inversions that trap pollutants close to the ground, carbon monoxide levels are often greatest during cold weather. Hemoglobin, the component of blood that delivers oxygen to cells, is bound to carbon monoxide when it enters the bloodstream from the lungs. It limits the quantity of oxygen that reaches the organs and tissues of the body.

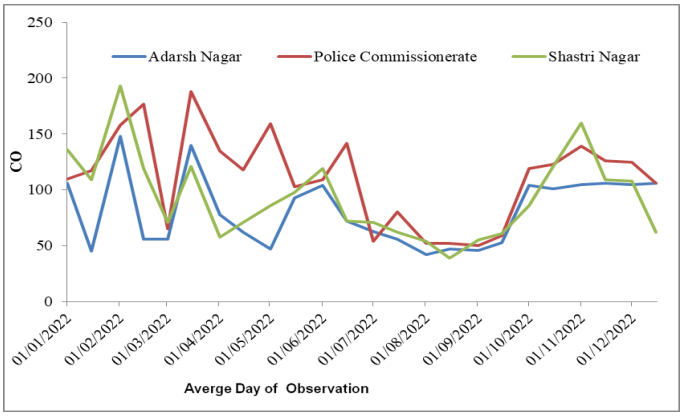

Figure 6 CO for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

The limiting value prescribed by WHO is not clarify but its value is limited by National Institute for Occupational Safety and Health (NIOSH) which is 35 ppm (40 mg/m(3)) as an 8-hour TWA and 200 ppm (229 mg/m(3)) as a ceiling. So its higher value more than ceiling in atmosphere is very crucial to human health.

The concentration of carbon monoxide for Adarsh Nagar, Police Commissionerate and Shastri Nagar is presented in figure 6. It is observed that the highest and lowest values in whole year are found at Adarsh Nagar is 148 (in February month) and 42 (in August), at Police Commissionerate is 188 (in March) and 52 (in August), at Shastri Nagar is 193 (in February) and 54 (in August). It is also observed that Shastri Nagar and Police Commissionerate are having higher concentration of CO in the starting months of the year its average low value in August and September.

3.8. Air Quality Index (AQI) of the observation area

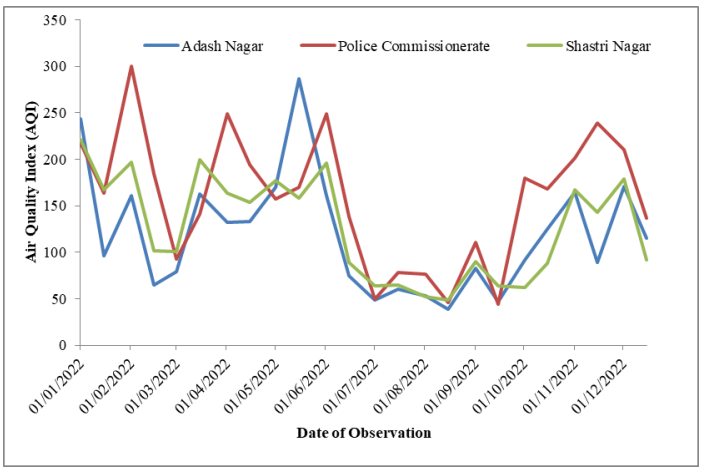

Figure 7 AQI for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur during 2022

The evaluated air quality index (AQI) of all three places is presented in figure 7. It is observed that the highest values of Adarsh Nagar, Police Commissionerate and Shastri Nagar are 287 (in May), 308 (in February) and 221 (In January) respectively. Similarly the lowest values in this queue are found as 39 (in August), 44 (in September) and 49 (in August) for corresponding places. The average value of AQI is evaluated for Adarsh Nagar, Police Commissionerate and Shastri Nagar in Japur city are 118.92, 158.30 and 126.71. According to WHO and table 1 these values are comes in moderately pollution and It may cause breathing difficulties for sensitive people or children / old persons with lung disease like asthma, and discomfort with heart disease.

4. Conclusion

The air pollution constituent data of PM2.5, PM10, NO_2, NH_3, SO_2 and CO are collected for Adarsh Nagar, Police Commissionerate and Shastri Nagar Jaipur from January to December 2022 from the CPCB website. The AQI is evaluated and found that the Jaipur comes into the yellow zone as per the average AQI assessment. But in some months of the year its value falls under green zone. But it is more thinkable or notable to the government and peoples living in Jaipur to implement the policies to reducing the air pollution. It is mandatory to increase the green belt in the area and action taken plan to be adopted for reducing the vehicle pollution.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

I would like to declare that no conflict of interest exits in this manuscript. The work described is original research and none of the material in this paper has been published or is under consideration for publication elsewhere.

Statement of ethical standard

All the ethical practices have been followed during writing.

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