# Removal of Air Pollutants By Photo Catalysis Using Titanium Dioxide In Chennai

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***Abstract-*** *Many cities in the world struggle with increasing air pollution which results in the formation of Smog which is one among the pollution causing factors.WHO shows that 9 out of 10 people breathe air containing high levels of pollutants[1]. Air pollution and population health related to it, is one of the main issues in Chennai in the past few years. Reason for that is a harmful emission which leads to creation of air pollutants like particulate matter (PM), sulphur dioxide (SO2), nitrogen dioxide (NOx), and creation of Ozone (O3). Nitrogen dioxide generated from vehicles is one of the most surrounding pollutants, which can be transferred from one form to another in the presence of sunlight. This study addressed the problem and identified the possible solution to improve the air quality by using innovative architectural approach in the urban core of Chennai. Basic ideology introduced in this study, considered outdoor applications of Titanium dioxide (TiO2) which is one of the most environmental friendly active photo catalytic material, in accordance with previously conducted studies. First part of the study was conducted by snowball research method which was used for collecting similar research materials. Further study was completed using explanatory research method along with mixed method research design which provides comparison and calculation of expected outcomes of applied new solution as a mean to reduce pollution. These innovative approaches were implemented as coatings of TiO2 on a Flyover, Pavement and Concrete Road of Koyambedu, as its daily traffic volume at its intersection was 1,72,999 [2]. Total area covered by TiO2 was 39,000m2. Results strongly indicate that usage of TiO2 coating reduced the amount of NOx emitted by vehicles per year by 95%. The amount of NOx removed after the analysis indicates that, proposed method in this study was very effective and can contribute to further analyses and lead to possible implementations in the near future.*

***Keywords***- Air Quality, Innovative Technology, Air Pollution, Titanium dioxide.

## I. INTRODUCTION

Air Pollution possesses a serious threat to the environment globally where the growth of rapid large industrialization without emission control is the main root cause. Together with a growth of urban and metropolitan areas, growth of population density and transportation related activities occur. Recent years are capturing continuous increase in the proportion of the population living in urban areas [3]. Chennai has been placed in the second position after Delhi with regard to vehicular pollution [4].Existing solutions for mitigating air pollution include decreasing emission at the pollution source by imposing stringent guidelines, reducing the energy by increasing the efficiency of electrical and other devices, going green, adopting control technologies and selective catalytic reductions. All these solutions have their own merits and demerits where an alternative approach is to exploit abundantly available building surfaces and it's near surroundings in the urban areas to mitigate air pollution. Apart from innovative solutions for future design, several researches done in the recent years are analyzing the performances on implementing titanium dioxide (TiO2) coating practices in the process of removing harmful air pollutants, by transforming them into harmless and environmentally-friendly air compounds (Figure 1) with the help of Photo catalytic Process which uses UV Light of Sunlight to accelerate the natural oxidation process.

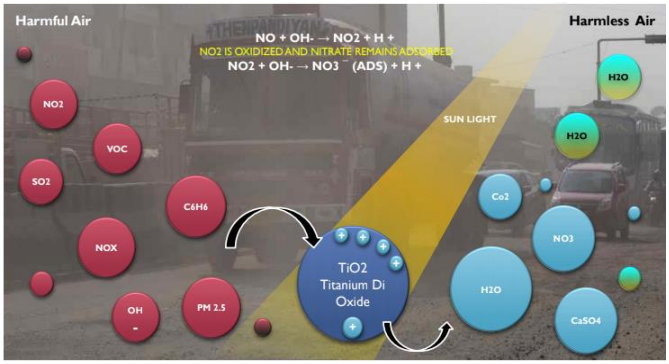


*Figure 1- TiO2, Capturing energy from sun light to depollute the air- Photo catalytic Reaction*

## II. RESEARCH METHODOLOGY

This research paper was addressed as a project study with explanatory research and mixed-method research design,

where quantitative data were followed up by qualitative. First part of this research paper was obtaining and analyzing the data regarding average vehicular emissions of NOx level, traffic volume and analyzing innovative methods regarding air quality improvements. Data was collected by snowball method and further content analysis from the records was done. Data regarding traffic counting in the proposed area of koyambedu used in this paper was obtained fromDetailed Project Report of Chennai's Metro project, while data about NOx emissions were taken from Tamil Nadu Pollution Control Board. Outdoor air quality improvement was done by removing NOx from the air emitted by vehicles in an innovative method. This approach includes application of TiO2 coats on the flyover surface, pavement and roads at a crowed main road of the urban core of Koyambedu, Chennai. After analyses of different studies by leading companies and experts that produce TiO2 coatings. Study proposed introducing coats of TiO2 on Flyover surface, roads and pedestrian paved areas in koyambedu urban core. TiO2 treatment serve as air-purifying function in the city that has constantly growing up as a problem with air quality, mostly due to expansion of its area, population and transportation system.

### A. Literature study

The study identified that, removal of NOx emitted by vehicles as a means of reducing air pollution using innovative approach defined as application of TiO2 coatings on different surfaces. In the past decade titanium dioxide (TiO2) emerged as an excellent photo catalyst material for environmental purification [5] . Research question covered all the possible of applying TiO2 coatings in order to increase air quality and analyzed the outcomes regarding effectiveness of this method. First step taken in order to answer addressed question was collection of data from already conducted studies regarding effectiveness of TiO2 coating in decreasing the amount of NOx in the air and reviews existing applications in practice. These studies were conducted by many top companies which were involved in producing TiO2 products applicable in different areas of indoor and outdoor, and on different surfaces like external walls, paved areas, roofs and roads. Based on the studies by Cristal Group, 1 m2 of surface painted with KNOxOUT coating may remove the NOx equivalent to 80g NOX per year [6]. Cristal Global painted 4,100 m2 of exterior wall as a trial at Manila's Guadalupe train station and found the paint removed about 26 g of NOX per 100 m2 of painted surface after application. Other trials that run over 4 years were, a wall in London of 135 m2 was treated with another Cristal product, and reported that reductions of 60% for the NOx. The photo catalytic paint is as also well reported to work in the low-light environment of multi-story parking lots, capturing 2.2 g of NOX per square meter per year [7]. According to a study on evaluation of titanium dioxide in removing air pollutants [8] , the removal rate for volatile organic species is about 60 cubic meters of air per day. It further states that "these numbers are rough estimates which cannot be taken into consideration as direct supporting data for approval, but are based on careful quantitative investigations". According to a study by Association for Emissions Control by Catalyst, Belgium, average emission of NOx for Euro 3 (BSIII) vehicles is 0.5 g/km [9]

### B. Selection of Site

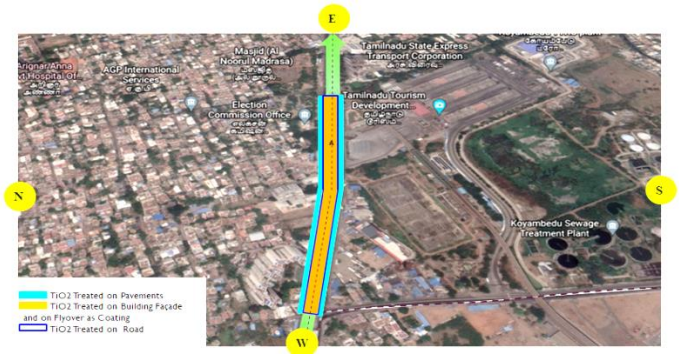


*Figure2 – Proposed TiO2Ttreatment at Koyambedu, Chennai.*

The site selected for this research was Koyambedu, as its daily traffic volume at intersection was 1,72,999 and ranked as second highest traffic area of Chennai [2] which is always filled with more traffic and pollution. Traffic counter states that in observed urban area of approximately 1km at Koyambedu more than 3000 vehicles daily, which represents 75 kg of NOx. The amount of NOx emitter per year in the same area is 2500 kg. The efficiency of TiO2 coatings was proposed in accordance to previous conducted studies about cleaning possibilities of different TiO2 products and the surface areas. To abate the air pollution, TiO2 was proposed in three different ways: Painting the new flyover surface, as paver block on pedestrian path and on concrete road.(Figure 2)

## III. APPLICATION OF SOLUTION

### 1. Fly Over

The basic principle is to coat the surface by titanium dioxide that fights pollution near the dense traffic zone. Crystal KNOXOUT is a new coating that can effectively reduce air pollution when applied near traffic ways on building surfaces. Application of this coating on the entire surface of the new flyover at Koyambedu (Figure 2) will give better results as there are many vehicular movements. The whole new flyover consists of the 20,000 m2 of titanium dioxide coated area. When TiO2 is treated to the flyover, the

whole surface of the flyover would remove 1250 kg of NOx per year out of 2500 kg of NOx emitted per year, or 50%.

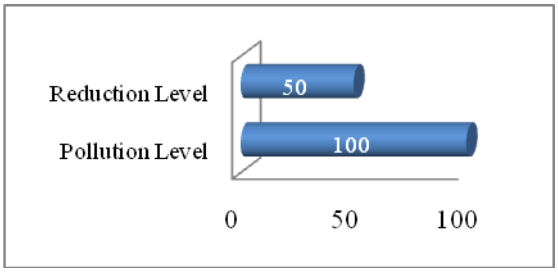


*Chart 1- Annual NOx removal percentage from Flyover Surface*
*(In kilograms)*

**2. Pavement**

Further setup implementation was applied on concrete paved pedestrian areas located next to the traffic zone on both the ways of road. Paver Blocks were made using TX Active Cement. Two of them are part of urban integration. TiO2 mix was applied on pedestrian ways in this part of the urban core. Total area with concrete pavement is 2000 m2. TIO2 Paver Block will decrease NOx for 500 kg per year, out of 2500 kg of emitted NOx per year, or 20%.


*Chart 2 - Annual NOx removal percentage from pedestrian surfaces (In kilograms)*

**3. Road**

Final setup implementation was a proposal for the flyover's road. To the conventional process of making a concrete road, mix of TIO2 using TX Active Cement was applied in this part of the urban core. Total area with concrete road is 17000 m2. TIO2 infused concrete road will decrease NOx for 625 kg per year, out of 2500 kg of emitted NOx per year, or 25%.

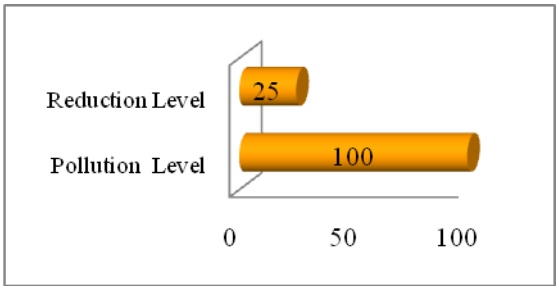


*Chart 3 - Annual NOx removal percentage from Concrete Roads*
*(In kilograms)*

**IV. DATA ANALAYSIS**

Total amount of emitted NOx per year in observed urban area of Koyambedu is 2500 kg. Proposed solution for reducing air pollution by applying innovative approach of TiO2 coatings would remove annual NOx emitted from the vehicles by 2375 kg per year – 95%

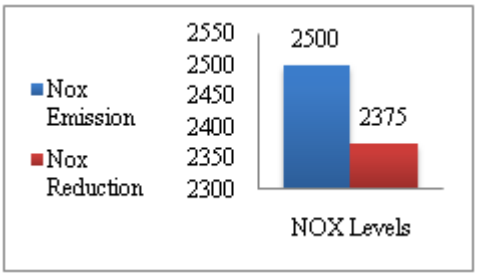


*Chart 4 - Annual NOx emission and removal (In kilograms)*

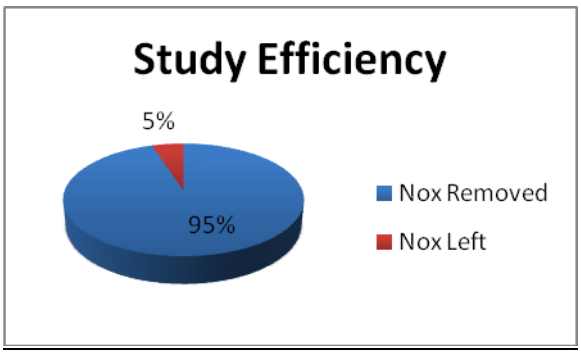


*Chart 5- Annual NOx removal by proposed setup (In percent)*

Regarding the fact that this study proposed treatment of flyover surface with total area covered by TiO2 of 20000 m2 , paved areas of 2000 m2 and Concrete road of 17,000m2 , results show that it removed more than half NOx emitted annually by vehicles that pass in this area. According to the percentage gained from the calculations we can state that application of TiO2 proved as effective. Since the most TiO2 coverage area was applied on flyover, it gave the best results in NOx removal. Negative side of application of TiO2 on pavements is implying that this method raises questions on

resistance of these coatings to the weathering but it is expected that problem can be solved since there are on-going researches regarding improvement of this issue.

### 1. Cost

Total area that would be coated by this research is 39000 m2. Average price for 4 kg of KONXOUT coating is Rs.2500. 1 kg of coating can cover 5 m 2 in two coats. This implies around 7000 kg of paint for the setup of this study, and led us to the cost of Rs.30,00,000 for TiO2 coating to be applied by this study (including labor cost). Total cost for applying TiO2 coating for this study would be Rs.30,00,000 that is for 39,000m2. According to the amount of removed NOx proven by this study we may say that the cost of applying TiO2 coating is acceptable.TIO2 induced Paver Block costs Rs.2,50,000. TiO2 induced Road cost Rs. 18,48,500. Overall cost required to implement this technique is around Rs. 60 lakhs.

### 2. Maintenance

This technology is simple to implement as, TiO2 does not get consumed in the process of photo catalysis, and theoretically it can be used indefinitely. The maintenance required is regular water cleaning during the dry season to resume good performance to avoid Renoxification. However, applying coatings of it on the pavement, and flyover surface suggests that layers of TiO2 can get damaged and it can affect their effectiveness. The main threats to the effectiveness of coating are those concerning pavements because people are walking directly over the coated area. This can affect durability because of traces of dirt caused by particulate matter. Nowadays, studies are being conducted in the best possible method to apply TiO2 coatings in which they will resist all possible causes of damaging it, including weathering, loads, or any other physical way of harm. There is a hope that this physical harm on TiO2 coatings along the pavements will be solved. Studies show that durability of the coatings ranges from 3-5years.

## V. FINDINGS AND CONCLUSION

The increased amount of pollution leaves negative consequences on human's health. Many, companies all over the world are trying to develop innovative sustainable approaches with a goal to remove dangerous compounds from the air, and decrease pollution. Study conducted in this research paper examines a possibility of application and implementation of air improving techniques regarding removal of NOx from the vehicles, using titanium dioxide coatings in the case study of Koyambedu in Chennai. Application was suggested in the parts of the urban core of the Chennai city with more traffic, which contains different possibilities in the methods of applications. Total amount of emitted NOx in this area is 2500 kg per year, and innovative approach of TiO2 application in this study removed NOx by 95%. According to the percentage of removed NOx together with acceptable cost of the TiO2 application, we can state that approach suggested in this study is very effective. Compared to mix of TIO2 on Paver Block and on roads, TIO2 infused coatings give better results. Since these studies are innovative and novelty in the world, this conducted research can improve complete understanding on this topic. Further, this study can serve as a basis for future analysis regarding case study of Koyambedu and one must know that photo catalytic applications are not effective everywhere. Good contact between the pollutants and the active surface is crucial and factors such as direction, wind speed and street configuration and pollution sources all play a very important role to abate the pollution.

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