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RISK ASSESSMENT TO OZONE EXPOSURE ON ELEMENTARY SCHOOL CHILDREN IN THE GEOGRAPHICAL ASTHMA PRONE REGION OF CAGUAS, PUERTO RICO

Partial requirement for the completion of
Environmental Management Science Masters Degree in
Environmental Risk Assessment and Management

By

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DEDICATION

This Thesis is dedicated to anyone that really cares about the future of humankind, my parents and my family.

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ACRONYMS, SYMBOLS & ABBREVIATIONS

AAFA: Asthma and allergy Foundation of America

CAA: Clean Air Act

CDC: Centers for Disease Control

DRNA: Departamento de recursos Naturales y Ambientales

EPA: Environmental Protection Agency

GLO: Ground level Ozone

IRB-AGMUS: Institutional Research Board- Ana G. Mendez University System

JCA: Junta de Calidad Ambiental, Puerto Rico

NAAQS: National Ambient Air Quality Standards

NCHS: National Center for Health Statistics

NEPA: National Environmental Air Policy Act

NESHAP: National Emissions Standards for Hazardous Air Pollutants

Nox: Nitrous Oxides

PPA: Pollution prevention Act

PPBV: Parts per Billion per Volume

PRDOE: Puerto Rico Department of Education

PREQB: Puerto Rico Environmental Quality Board

PPMV: Parts per Million per Volume

SPSNSS: Source Performance Standards for New stationary Sources

VOC: Volatile Organic Compounds

ABSTRACT

Ozone, an EPA criteria air pollutant is a known asthma trigger when encountered at specific concentrations at ground level. Ground level ozone was measured at Paula Mojica Elementary Community Public school in the Municipality of Caguas, Puerto Rico for a period of two weeks for eight hours a day during school hours in order to determine if high levels of ground level ozone were triggering asthma attacks among asthma prone students. The school is located near a heavy traffic roadway in the center of the Caguas Township. Ozone measurements were compared with National Ambient Air Quality Standards (NAAQS) to determine if the school was being subjected to elevated levels of ozone and a validated IRB-AGMUS & DOEPR approved questionnaire was provided to the parents of school children to determine how many were asthmatic. The results show that the levels of ground level ozone at the school were well below the NAAQS and thus, for the duration of the thesis research, ozone does not appear to pose an environmental risk to asthmatic students attending Paula Mojica Public School. This is the first time that ground level ozone is measured at a Public school in Puerto Rico.

RESUMEN

Ozono, uno de los contaminantes ambientales designado como crítico por la *EPA* se conoce por ser un detonante/ desencadenante de asma al este encontrarse en concentraciones especificas a nivel del suelo. El ozono a nivel del suelo fue medido en la Escuela de la Comunidad Paula Mojíca. Esta escuela pública de nivel elemental se encuentra localizada en el Municipio de Caguas en Puerto Rico cerca a una vía de rodaje primaria de alto flujo vehicular en el centro del Municipio de Caguas. Durante un período de investigación que duró dos semanas, medimos el ozono rastrero durante ocho horas al día para determinar si el ozono, producto de la contaminación atmosférica, presentaba algún riesgo de desencadenar episodios de asma en la población escolar. Los resultados fueron comparados con los estándares de ozono permisibles por los Gobiernos de EU y PR para determinar si la escuela se encontraba expuesta a niveles elevados de ozono. Proveímos un cuestionario validado por el Sistema Universitario Ana .G. Méndez y el Departamento de Educación de Puerto Rico a los padres de los estudiantes para determinar cuántos niños asmáticos hay en la escuela. Los resultados obtenidos demuestran que el ozono rastrero no presenta ningún riesgo ambiental a los niños asmáticos que atienden clases en la Escuela de la Comunidad Paula Mojíca. Esta es la primera vez que el ozono rastrero es medido en una escuela en Puerto Rico.

CHAPTER I

INTRODUCTION

Background

The modern onset of urban sprawling and overpopulation being experienced by many countries around the world are increasing the levels of air pollution and allergens with consequentially adverse effects on pulmonary development in children (Gauderman, et al, 2004). As a consequence, there has been a sharp increase in the global prevalence, morbidity and mortality associated with asthma for the last 40 years. It's estimated that 300 million people are being affected worldwide by the disease (Peters, et al. 2006) and its prevalence is increasing by 50% every decade (Braman, 2006).

Asthma is a chronic respiratory disease characterized by episodes or attacks of inflammation and narrowing of small airways in response to environmental triggers. Some of the symptoms include shortness of breath, cough, wheezing, chest pain or tightness, or a combination of these symptoms. Worldwide studies on asthma, by different research groups, have demonstrated the excessive mortality and morbidity (Dockery et al, 1993; Pope *et al*, 1995; Bates et al, 1990; Pope, 1 991; Raizenne et al, 1996; Boezen et al, 1999;; Samet et al, 1992; Schmitzberger et al, 1993; Ostro et al, 1996) associated with increased air pollution (Farhat et al, 2005).

Epidemiological studies have definitely been able to link air pollution as the environmental exposure that triggers asthma in children (Lebowitz, 1996). Worldwide estimates for asthma prevalence in developed countries range from 7% in France and Germany, 15-18% in the United Kingdom and 11% in the United States (Peters et al,

2006). In North America, 10% of the population has asthma (Braman, 2006). This respiratory disease is the most common chronic disease among children between the ages of 5-17 years of age affecting 8.6 million people in the United States alone (NCHS,2003). Most asthma sufferers are under age 18 and the prevalence of the disease is most common among male than female children (NCHS, 2003).

Puerto Ricans currently occupy the first position among the United States of America in reported cases of pediatric asthma (AAFA, 2005).This constitutes 32% of diagnosed asthma cases among the total for the population and all minority groups in the USA *versus* 12.6% of the USA population under 18 years of age (Halterman et al, 2004).

Among the known asthma triggers, ground level ozone has become a significant pollutant as a result of increased population growth, industrial activities and the massive use of motor vehicles. In Puerto Rico private transportation is favored over public and collective transportation systems. As a result, the government has pushed a massive building of roadways to accommodate the ever increasing burden of automobile use on the island with over 2.8 million vehicles registered (Lobato et al, 2005).

Over 12.8 million school days are lost every year due to asthma in the United States (Mannino et al, 2003). This represents approximately 8 days for each asthmatic student. In 2004 the CDC stated that nearly 44% of all asthma hospitalizations involve children (AAFA, 2002) thus becoming the third ranking cause for hospitalizations in the United States (NCHS, 2004).

Research problem

Ozone is an extremely reactive form of oxygen that occurs naturally in the Earth's upper atmosphere between 10-30 miles above the surface of the planet where it forms a protective layer that shields us from the sun's harmful ultraviolet rays. In the lower

atmosphere, near ground level, ozone is formed when hydrocarbon pollutants emitted by cars and other sources derived from internal combustion engines react chemically in the presence of sunlight. Ozone at ground level is a harmful pollutant that if allowed to build up to dangerous concentrations can trigger asthma attacks (Bell et al, 2004).

The Caguas municipality is currently one of the most developed regions in the Island with a continuous influx of people and motor vehicles that, together with the expansion of roads and motor ways, are creating an unmeasured burden of environmental pollutants as ozone.

Asthma sufferers are the only segment of the population that has been identified to respond acutely to ozone exposure (Lewis et al, 2005). Although the large amount of emissions produced by motor vehicles fueled by fossil fuels and the corresponding environmental burden of ozone have been previously studied (Fauroux et al, 2000, Just et al, 2002), there have been no reports of these studies in Puerto Rico. Ozone is being monitored in Puerto Rico by the Puerto Rico Environmental Quality Board in the town of Cataño for air quality analysis only. It is used to monitor nitrous oxides, ozone and particulate matter emanating from the smokestacks of an electrical power plant which is located on the north coast of the island at a distance of 17 miles from Caguas.

Ozone has not been monitored for health related issues in Puerto Rico and the Air Quality Index for ozone is not monitored in any school or school district in the geographical region of Caguas or in Puerto Rico as a whole. Therefore, this study is directed to evaluate the relationship between ozone on asthma prone children in Puerto Rico.

Since most public schools in Caguas are located near primary and secondary roads, it is necessary to ascertain if there is a feasible risk on children's health due to ozone pollution in elementary schools. In this study, a risk assessment will be determined for

ground level ozone exposure on an elementary public school located near a primary roadway in an urban setting in the geographical region of Caguas.

Justification

In Puerto Rico the relation between increased levels of asthmatic children in the geographical region of Caguas in elementary schools and the localization of most elementary schools near primary and secondary roads has never been evaluated as a risk factor towards exposure to ground level ozone. The role of ground level ozone exposure in the epidemiology of asthma sufferers has been explored in various countries but not in Puerto Rico (Bates et al, 1990; Gauderman et al, 2002; Hwang et al, 2005; Janssen et al, 2003).

Scientists in Paris, France have demonstrated a significant relationship between emergency room visits for acute asthma in children less than 15 years old when exposed for several days to higher levels of ozone (Faruroux B, 2000). In Puerto Rico the high prevalence of pediatric asthma among elementary school children has not been evaluated against sources of anthropogenic ozone as a possible culprit for increased asthma reports. The geographical region of Caguas by 2003 was standing as the fourth largest municipality in Puerto Rico with the largest reported asthma prevalence (Departamento de Salud Puerto Rico, 2003).

Research Question

Are asthma prone children in elementary public schools exposed to ground level ozone concentrations at higher risk for asthma attacks?

Goal

To determine if ground level ozone presents a risk on the pediatric health of elementary school children while attending school in the geographical region of Caguas, Puerto Rico.

Objectives

1. Identify and quantify the presence of ground level ozone in a selected elementary school near a primary road.
2. Evaluate the level of ozone and correlate with the incidence of asthmatic episodes in children.

CHAPTER II

LITERATURE REVISION

Historical background

The health effects of air pollution are recognized as a major public health concern by most worldwide health organizations and professionals in the asthma field. Worldwide health situations have been studied ever since the onset of the industrial revolution. The first recorded case of deaths caused by air pollution occurred during the winter of 1873-74 in London, England. A fog saturated with pollutants lasted from November to February trapping all sorts of unidentified toxics that caused the average death toll to rise by 75% during the period of four months. In the Meuse valley in Belgium during December 2-5, 1930, a thermal inversion event caused the deaths of 60 people in three days. About 30 different chemicals were identified as the potential culprits and the death toll rose about 10 times above normal rates (Firquet, 1931). In 1934 in London England, many accidents occurred due to a heavy polluted fog (MacAdie, 1934). In 1948 in Donora, Pennsylvania weather conditions caused toxic gases from industrial and domestic furnaces to float above Donora causing the deaths of 20 people and sickening around 6,000 people. In London, again, 12,000 people died in 1952 due to a killer fog that trapped sulfur dioxide and pollutants (Logan, 1953). In 1966 about 400 people died in New York City due to extreme smog conditions. The last event reported was in 1975 Pittsburg, Pennsylvania when 14 people died due to a four day smog event. Pollution events of historical magnitudes have forced various elements on the society to try to ascertain and correlate such disastrous events with certain and /or specific substances, compounds or chemicals in the environment that were responsible for sickening people.

In all of the above mentioned events those that succumbed first were those who suffered from various types of respiratory diseases or appeared to have compromised immune systems due to illness or allergies.

It is widely known that both Los Angeles County in California, Mexico City in Mexico and Teheran in Iran are probably three of the most heavily polluted cities in the world. This is due to the geographical location of these cities in valleys that are surrounded by mountain ranges that do not permit the influx of fresh air into the valley therefore, heavy pollution production and the inability of the prevailing winds to dissipate the pollution from the air makes these countries the worlds most susceptible and polluted.

The geographical region of Caguas presents practically the same conditions from these places and is being subject to almost the same types of pollutants, although not at the same degree. Most particulate generators in the industrialized nations are being placed under strict control by respective governments, the ever increase use of motor vehicles as a means of transportation continues to increase the levels of ground level ozone. Ozone is formed when the byproducts of nitrous oxides (NOx) and volatile organic compounds (VOC) combine chemically with oxygen and ultraviolet light. These by products are the end result of burning gasoline and coal. Ozone has only in recent years been considered as definite trigger for asthma and it is one of the six Environmental Protection Agency (EPA) criteria air pollutants.

Ozone Formation

Ozone is a molecule of three oxygen atoms bound together. It is an unstable and highly reactive molecule that is used in industrialized processes for bleaching, deodorizing and sterilizing water. At low concentrations it is a toxic substance. Ozone is found naturally in small concentrations in the stratosphere, which is a layer in the earth's upper atmosphere. It is form when ultraviolet light from the sun splits an oxygen

molecule into two atoms and each atom then binds with an oxygen molecule to form ozone. This stratospheric ozone has been called “good ozone” because it protects earth’s surface from ultraviolet light radiation. Ozone can also be found in the troposphere which is the lowest layer of the atmosphere.

Trophopheric ozone is manmade and is the result of combustion processes that involve fossil fuels being burn in internal combustion engines and power plants. Automobile exhaust and industrial emissions release a family of nitrogen oxide gases (NOx) and volatile organic compounds (VOC) that are by- products of burning gasoline and coal.

VOC + NO_X + heat + sunlight = ground level ozone (O_3)

These are combined chemically with oxygen to form ozone during sunny, high temperature conditions of late spring, summer and early fall. High levels of ozone are usually formed in the late afternoons and early evenings, dissipating during cooler nights. Although ozone pollution is formed mainly in urban and suburban areas, it ends up in rural areas as well, carried by prevailing winds or resulting from cars and trucks that travel into rural areas. Significant levels of ozone pollution can be detected in rural areas as far as 250 miles (9150km) downwind from urban industrial zones (Kim et al, 2005). This type of environmental pollutant is known as an asthma trigger and is currently being investigated as such in many countries globally. In today’s developed world where population growth and dependence on motor vehicles is increasing, the role of tropospheric ozone is taking prevalence among other criteria pollutants, especially in urban areas where pollution levels are increasing drastically.

Ozone & Health

The possible reasons that led individuals to suffer from asthma vary from the simplest to the complex. For this reason the scientific community is still learning just how dangerous ozone can be. Bell et al, 2004 and Gryparis et al, 2004 concluded on their respective investigations that short term exposure to ozone can kill, since ozone reacts chemically with lung tissue. As a basis for research on the interrelation of ozone with soft cell tissues, studies of genetic polymorphism in the chromosomal regions of the human body that are related to asthma are being evaluated as a possible risk factor to the pulmonary response to air pollutants as ozone (McCunney, 2005). Bio-aerosols that can act as inflammatory mediators for asthma mechanisms (towards ozone exposure) are being considered and it seems that asthmatics with the null genotype for the antioxidant GST seem to be more at risk of the ozone related decrement of pulmonary function (McCunney 2005; Romieu et al, 2004)) when exposed to environmental pollutants. It seems that the asthma condition tends to aggravate when inflammatory mediators (oxidants) combine with particle pollution (in synergy) creating a strong asthma trigger in vulnerable children. In comparative studies done in animals, it seems that exposure to ozone seems to impair lung development by means of inflammation, disruption of growth factors, fibrosis, and modification of the lung architecture (Schelegle et al, 2003; Barr et al, 1990). Environmental conditions such as cool temperature and particle concentration also seem to exacerbate asthma attacks (Balmes, 1993).

Recent studies also suggest the importance of internalizing disorders as depression and anxiety in Puerto Rican children and the asthma condition (Ortega et al, 2004; Feldman et al, 2006). When analyzing all the environmental risk asthma triggers and the behavioral factors of the above mention studies, the basis for a formidable cocktail of elements develops in such a way as to render vulnerable children to suffer and possible

succumb to asthma attacks. Continuous research into the specific vulnerabilities and effects of ozone in children continues in a worldwide manner due to the increase of both cities and automotive traffic (Gauderman et al, 2004). The specifics of the ozone potential for asthma are still being investigated.

Ozone & Asthma

The relation between outdoor air pollution and asthma has always been a major focus of research. Traffic exhaust has become a major source of pollution due to the rapid urbanization of the land. Numerous studies have shown an association between traffic density and increased air pollution on respiratory health (Delfino, 2003; Kim et al, 2005). The World Health Organization reported on 2002 that 3 million people die each year from the effects of air pollution. This is three times (3) the number of people that die on automobile accidents each year globally. Air pollution claims around 70,000 lives annually in the USA alone and continues to threaten people around the world. New evidence shows that traffic exhaust and ozone may be responsible for new incident cases of asthma (Wong et al, 2004). In Taiwan, a study of Taiwanese school children exposed to traffic related air pollution and ozone have demonstrated that there is an increased risk to ozone when combined to other traffic related pollutants (Hwang et al 2004). The study determined that the risk of childhood asthma increased according to increased annual levels of ozone. In Southern California a children's health study found that children living within 250 feet of mayor roads had a 50% higher risk of having asthma symptoms (McConnell, 2006). In San Francisco and San Diego in California, it has also been found that there is a statistical significant relationship between traffic related pollution and respiratory symptoms in children (Kim et al, 2005). While in France the results of a long term study in five metropolitan areas have concluded that traffic related pollutants have contributed to the current asthma epidemic (Zmirou et al, 2004).

In Germany a study that encompassed around 3,700 children found evidence that levels of asthma increased between 50-60% with frequent truck road traffic (Duhme et al, 1996) while a similar research in Holland carried out in 13 schools located within 1,000 meters from mayor highways (Janssen et al, 2003) came up with the same conclusions as the above mentioned study in Germany (Van Vliet et al, 1997). In Dresden, Germany a study of over 5,000 children demonstrated a relationship between traffic-related pollutants and the prevalence of cough and bronchitis during the morning hours of vehicle traffic and in home school attendance (Hirsch et al 1999). In Nottingham, England, research was done to examine the relationship between living near a main road and the incidence of asthma in over 6,000 children. It was determined that children living within 500 feet (150 meters) of the roads suffered increases between 8-16% per 30 meters (100 feet) and that most of the risk involved falls within 90 meters (300 feet) of the road. A study in Austria determined that the increase in risk was about 30% in rural communities (Studnicka et al, 1997) exposed to traffic-related pollution.

Recently, a small body of scientific evidence suggests that motor vehicle air pollution impairs long-term lung development (Gauderman et al, 2002). The vast majority of these studies have found strong associations between health issues relating to asthma and increases in the use of motor vehicles at around 200 meters (600 feet) near schools,. High traffic volumes and truck traffic appear to be the determinant risk factors associated with asthma exacerbations among schoolchildren. Epidemiological studies have also found that long term exposure of high levels of motor vehicle pollution has led to reduced lung function. Children tend to inhale more air than adults and as a result they extract more ozone from the air they breathe.

Legal background

In the Commonwealth of Puerto Rico, the legal entities responsible for environmental subject matter and air quality issues related to ground level ozone are:

Federal Government (USA)

The Clean Air Act, (CAA), 42 U.S.C. s/s 7401 et seq. (1970)

This is a comprehensive Federal law that regulates air emissions from area, stationary and mobile sources. This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. The law sets goals for the attainment of maximum levels of permissible pollutants in the environment by directing states and territories to develop state implementation plans (SIP) applicable to appropriate industrial sources in the state.

The Clean Air Act (CAA), 42 U.S.C. s/s 7401 et seq. (1990) amendment

Was in large intended to meet unaddressed or insufficiently addressed problems such as acid rain, ground level ozone, stratospheric ozone depletion, and air toxics.

National Ambient Air Quality Standards 40 CFR part 50, section 109 (NAAQS)

The Clean Air Act established two types of national air quality standards for ground level ozone (Table 5)

- **Primary standards** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- **Secondary standards** set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.

The Clean Air Act requires the review of the latest scientific information every five years. Changes to the ozone standard have been proposed for June 20, 2007 with the intention of lowering the standards from 0.08 ppm to 0.060 -0.070 ppm for the primary 8-hour standard.

The National Environmental Policy Act (NEPA) 42 U.S.C. s/s 4321-4347et seq. (1970).

The purpose of this act is to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality and to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the nation….

Pollution Prevention Act, 42 U.S.C. 13101 and 13102, s/s et seq. (1990) Part B. ozone o protection (replaced by title VI) stratospheric ozone protections.

This act focuses on the industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use (source reduction)

Commonwealth of Puerto Rico (USA)

Constitution of the Commonwealth of Puerto Rico. Article VI, Section 19

The referred article relates to the constitutional mandate that relates to the protection of natural resources. This relates to the Air that we breathe every day as it is a natural resource.

Ley Sobre Política Pública Ambiental. (Environmental Policy Act) No. 416 of September 22, 2004. (P.of REC. 4790, 2004), Law 416.

This law authorizes the Puerto Rico Environmental Quality Board to determine air quality on the Commonwealth. It promulgates laws that establish the necessary requirements to control the emission of air pollutants administrate federal programs and adjudicate operation permits to pollution emitters as required by section 501 of CCA (control de contaminación del aire).

Reglamento para el Control de la Contaminación Atmosférica No. 5300 of August 28, 1995

This law sets the standards and requirements to preserve the natural quality of the air and to prevent and eliminate air pollution. It defines air pollution based on EPA – NAAQS, SPSNSS and NESHAP. It also regulates stationary and non stationary source pollution generators by means of permits based on visible emissions.

Ley Orgánica del Departamento de Recursos Naturales y Ambientales (DRNA) (Law No. 23 of June 23, 1972) (3 L.P.R.A. 151-163)

This law establishes the above mentioned agency with the purpose of protecting the natural resources of Puerto Rico according to article 19 of the Constitution of Puerto Rico together with the PR Environmental Quality Board (JCA). The Environmental Protection Agency (EPA) and the Puerto Rico Environmental Quality Board (JCA) have an accord relating to Clean Air in the Commonwealth. EPA supervises and provides implantation criteria and reports to the respective authorities and JCA administers the majority of the air quality programs in Puerto Rico.

All the above mentioned laws and regulations clearly establish a direct mandate to regulate pollution emissions in Puerto Rico. Both Commonwealth and Federal

Government regulations are designed to protect not only the environment but also the living organisms that are part of our ecosystem to which human beings also belong.

CHAPTER III

METHODOLOGY

Study area

The municipality of Caguas is located in the central eastern mountainous region of Puerto Rico (18º15'49"N & 66º2'30"W) covering 58 square miles and 38,628 acres and possessing a sub tropical moisture type of environment. Caguas encloses the largest of the Puerto Rico interior plains known as the Caguas Valley. It covers an area of 51 Km^2. It is surrounded by the Puerto Rico Central Mountain Range to the west, the Cayey Sierra to the Southeast and the Luquillo Sierra to the Northeast. With an average population density of 140,502 persons (US census 2001) it is becoming one of the most densely populated regions in Puerto Rico with expanding roadways and air pollution. It has a humid-tropical type of weather system that is enclosed by mountain ranges with predominately eastward winds that are trapped by the surrounding mountains creating a microclimate unique to the region. It has an average rainfall between 1000 and 2200mm of precipitation and a relative average temperature between 18° and 24ºC.

Objective 1:

Identify and quantify the presence of ground level ozone in a school near a primary paved road.

One school was selected at random (among 50 schools) near a primary road in an urban setting. Ground level ozone was measured with a 2B technologies ozone monitor for 9 days for a period of eight (8) hours from 6:00 am to 3:00 pm. The Selected school was the Paula Mojica Community School located in Caguas, Puerto Rico (Appendix 1,

2). It was expected to determine if the EPA National Ambient Air Quality Standards for Ground-level Ozone were being met (Table 5).

Objective 2:

To correlate ground level ozone concentration with increased incidence of asthmatic children.

The IRB–AGMUS validated questionnaire (Appendix 4) was provided to school children to find out how many were asthmatic. Statistical analysis of the results for both ground level ozone and missed school days was analyzed to determine if there was a casual or spatial relationship between the two variables object of this study.

The research study was carried out during two consecutive weeks during the month of March 2007. Before the start of the study, an informative letter addressed to the parents and the faculty of the school was sent out to inform all interested parties about the measuring equipment that was to be located in front of the school (Appendix 5). The first set of data was obtained during the 5 - 9 of March 2007 and the second set of data was obtained during the 12 - 16 of March 2007. An Ozone monitor from 2B technologies, Inc. Model 202 was located in front of the primary school building at Paula Mojica School facing the street where the school is located and downwind from Highway PR-1 (Appendix 3, 9, 10). The set height for the position of the Ozone monitor was 25 Inches from the ground (Appendix 6, 8). The Ozone measurements were set for logging the mean average of six -10 seconds measurements per minute in ppbv (parts per billion per volume). The first 20 minutes of every measured daily set of measurements was not used in the final average of ozone lectures due to the amount of time that is required for the lamp, photodiode, and the internal temperature of the absorption cell to stabilize. During the first school week of five days, only four days were measured due to school

day interruption due by official PRDOE activities. Data logging for ozone was started around 7:00AM every day.

After two weeks of data logging ground level ozone measured taken in ppbv, and averaged six measurements per minute, the IRB-AGMUS student's questionnaire (Appendix 4) and the IRB-AGMUS parental consent form (Appendix 11-12) were handed out to school officials for dissemination to all students, parents or custodians and see how many were willing to cooperate or participate on the research study. These consent forms included additional parental consent forms for school records as requested by PRDOE policy (Appendix 13, 14). The data analysis was performed by direct annotation and grouping of similar elements within the sampled population.

CHAPTER IV

RESULTS AND DISCUSSION

This research study was focused on finding out if ground level ozone was responsible for asthma related absenteeism at Paula Mojica Community Public School. The school is located inside an urban setting (Appendix 1) and is exposed to constant air pollution, being ozone one of them. Epidemiological studies have been able to link ozone, a component of air pollution, as an asthma trigger. The strategic location of Paula Mojica Public School (Appendix 2) presented the opportunity to start investigating pediatric asthma attacks due to environmental pollution among elementary school children in the Caguas municipality. This type of research has never been done before in Puerto Rico. The data obtained was measured during the month of March, 2007. Accomplishments on this Endeavour are discussed as follow:

Objective 1: The presence of ground level ozone (GLO) was measured for nine days divided into two school weeks for a period of 8 hours a day between 6:00 AM to 3:00 PM. The data obtained was divided in individual tables for each measured day (Tables 8-15). Each individual measured value for ozone represents an average of six 10 second measurements per minute. The ozone measurements were then averaged for easing the analysis part of the research (Table 1) and were compared to the National Ambient Air Quality Standards (NAAQS) (Table 5) after being converted from ppbv to ppmv. The conversion standard was necessary due to the fact that the ozone monitor only reads data in ppbv and the NAAQS are in ppmv. Ozone was found to be present on school grounds due to the location of the school near an urban primary road with a peak traffic load of 2,595 motor vehicles per hour (PRDOT, 2005). The results for the ozone

measurements (Tables 9-17) show that the school grounds are under constant exposition of GLO with variations as low as -7 ppbv (-0.007ppmv) to as high as 40.8 ppbv (0.04 ppmv) among the ozone totals for the experimental GLO measurements when all the anthropogenic factors are considered.

The results for GLO exposure at Paula Mojica Community Public School demonstrate that the ozone levels, when averaged, were found to be below the 0.08 ppm NAAQS set by both EPA and the Puerto Rico Environmental Quality Board (PREQB). If the results are not averaged, then most of the observed readings for GLO remain above the NAAQS. The ozone measurements for week one show a weekly average deviation of 0.062 ppmv from the primary ozone standard of 0.08 ppm/ hour (Table 7) and a weekly average deviation of 0.064 ppmv for week two (Table 7). Although there is a strong presence of GLO on school grounds, when the measurements are averaged and compared to the NAAQS (as required by law & EPA standards), the ozone concentration becomes diluted and thus the presence of ozone becomes somewhat insignificant for the two weeks of measurements at the school. Therefore, a Risk Management Plan (RMP) for GLO is not necessary. This ozone dilution dispersal is clearly observed when the data is graphed (Figures 1-9) against the time duration of the data gathering events.

When analyzing the graphed data (Figures 1-9) the first thing that is noticed is the similarity in ozone distribution among the corresponding days of the week. that, With the exception of Wednesday (there was no measurement taken on Wednesday for the first week) the distribution dispersal pattern comparison for ozone on Monday-Monday, Tuesday-Tuesday, Thursday -Thursday and Friday-Friday, are very similar. This could be due to the consistent weather factors encountered through the data gathering event. As recorded on Table 8, the average high temperature was 85.5º F, the average low was constant at 61ºF for the two weeks and the average wind speed was 4.28 MPH (table 6).

The ozone dilution situation is not the only issue with the averaging of the data. The daily wind current that flow towards the school from the mountains also seems to prevent the concentration of high levels of GLO on school grounds. Wind flow from a westerly track at an average speed of 4.2 MPH (Appendix 3, 7) seems to neglect the possible effects of GLO on asthmatic children when the wind travels through school grounds at constant rates.

On the other hand it is the same westerly wind tract that appears to bring ozone as air pollution from Highway PR-1 (Appendix 3). Calculated constant wind speed averages for weeks one and two during ozone data gathering events were 4.2 MPH and 4.36 MPH respectively (Table 6). And thus, it is the same westerly wind tract that disperses and dilutes the dangerous concentration of ozone on school grounds. Average temperatures of 85°F for week one and 86°F for week two (Table 8) plus plenty of sunlight appear to have contributed to peak production of high levels of ozone that appeared at random intervals throughout the data acquisition that were found to be above NAAQS. This was true during peak traffic hours in the morning, mid day and at school closing time when students are dropped or picked up by their parents but these ozone peaks become diluted when the data is averaged and compared to the NAAQS.

Objective 2: An IRB-AGMUS validated questionnaire was provided to school children to find out how many were asthmatic. The sample size was attained at 133 participating students whose responses to the IRB-AGMUS validated questionnaire are described in table 18. The quantification of the data seem to suggests that although there is a significant number of asthmatic children, these do not appeared to be suffering from GLO induced asthma attacks since the recorded concentrations at Paula Mojica school were below the NAAQS during the duration of the thesis research (Figures 1-9). What's true is that around 40% of the asthmatic students are not receiving medical treatment

and 37.73% do not receive medications to treat the asthma condition (Table 18). These might explain in part the reason as why some students at Paula Mojica Community School are suffering from asthma episodes since their respective conditions might be originating at their homes or somewhere else. Maybe the asthma exacerbations are related to the amount of airborne particulate matter in school grounds or other anthropogenic factors not investigated on this thesis research.

It is of noticeable concern that during the first week of monitoring (5-9 of March 2007) the whole of Puerto Rico was being covered by a large amount of volcanic ash and sulfur dioxide coming from Mount Soufriere eruption recorded on march 1st 2007 in the island of Montserrat located east of Puerto Rico (GVP/USGS, 2007). As reported by school personnel, the large number of absenteeism during this period was due to respiratory ailments related to particulate matter. Also it is important to notice that although Puerto Rico does not have noticeable changes in seasons, between the months of November and April, the wind and the temperature seem to be stronger and colder. These two environmental indicators are known to cause changes in atmospheric ozone creation.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The presence of GLO is constant on school grounds but it does not appear to be causing any significant medical inconveniences nor triggering asthma attacks. Therefore, the proposed regression analysis to determine how many asthmatic children were suffering due to ozone pollution was not necessary. This is due to the fact that the location of Paula Mojica Community Public School allows for westerly trade winds to dissipate ozone and thus, not allowing it to achieve dangerous levels above or near the NAAQS. This conclusion is true for ozone measurements taken outside the classrooms since it was impossible to measure indoor ozone pollution inside classrooms due to the high noise levels produced by the ozone monitor used on this thesis research. This was a significant limitation.

A constant wind current seems to benefit Paula Mojica Community Public School from high levels of ozone pooling on school grounds but then this seems to be true only when the wind is actively blowing which was the case during the duration of the research. It would be interesting to acquire three or four ozone monitors and take simultaneous readings from inside the office building and classrooms (with and without air conditioning) for at least a year. In that way ozone, temperature, and wind speed and direction can be measured during the different seasons of the year and a clear and precise picture of the situation can be obtained. Also, the distance of the main road from the school grounds is well over 500 feet which is the minimum measured distance estimated by a study in southern California (McConnel, 2006) which declares that at 250 feet the risk of asthma attacks increases drastically. In conclusion, during the two weeks of experimental measurements, it seems that GLO does not represent an environmental

risk to Paula Mojica Community Public School and therefore, a Risk Management Plan is not necessary for Paula Mojica Community Public school.

Although the presence of ground level ozone was measured, recorded and analyzed, there seems to be additional environmental factors that need to be investigated that might be affecting the health of asthmatic students at the school. Particulate matter and the presence of mold on school grounds need to be measured and their respective risk assessment has to be evaluated against known prevailing medical conditions suffered by some students at the school. School personnel have reported that during heavy dense particulate days, absenteeism at the school is very high; this can be observed in table 2 when the Caguas region of Puerto Rico was being blanketed by volcanic emissions from mount Soufriere volcano in Montserrat. The Caguas municipality also suffers from thermal inversion events due to its location on an alluvial plain surrounded by mountains.

This thesis research is the first one in Puerto Rico that has measured Ground Level Ozone on an elementary school.

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TABLES

Table 1

Ozone averages in ppm for each recorded 8 hour day (converted from ppbv).

Ppbv/1000 = ppm (v)

Week one

Date	**Ozone measurement**
3/5/07	0.01845 ppm
3/6/07	0.01486 ppm
3/7/07	no measurements taken/ no classes.
3/8/07	0.02103 ppm
3/9/07	0.02117 ppm

Week two

Date	**Ozone measurement**
3/12/07	0.0233 ppm
3/13/07	0.0145 ppm
3/14/07	0.0226 ppm
3/15/07	0.0260 ppm
3/16/07	0.0192 ppm

Table 2

Absentee Paula Mojica student totals during the study period. Non asthma related

---

Week 1

From 3/5 – 3/9/ 07

Four days total

Female	**Male**	**Total**
48	61	109

Week 2

From 3/12-3/16/07

Five days total

Female	**Male**	**Total**
29	26	55

Table 3

Student's questionnaire accumulated totals. N= 133.

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2) Household location

Urban	**Rural**	**Industrial**
110	20	1

3) Sex

Male	**Female**
63	68

4) Age (in years)

5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	17	22	26	22	17	15	7	1

5) Diagnosed as asthmatic

Yes	**No**
45	88

6) Receiving treatment

Yes	**No**
27	101

7) Use of medication(s)

Yes	**No**
28	100

8) Believe that the following cause asthma

Dust	**Medications**	**Pollen**	**Air pollution**	**Insecticides**
53	1	21	49	16

Mold	**Humidity**	**cleaning products**	**Cigarette smoke**	**other**
13	32	23	29	0

Table 4

Conversion of recorded ozone data from ppbv to ppmv.

Values do not include the first 20 minutes of recorded Ozone averages due to equipment calibration after start up.

Ppbv/1000 = ppm (v)

Week one

Date	Ozone average (Ppbv)	Ozone average (Ppmv)
3/5/07	18.4502	0.01845 ppm
3/6/07	14.8674	0.01486 ppm
3/7/07	N/A	N/A
3/8/07	21.0344	0.02103 ppm
3/9/07	21.1701	0.02117 ppm

Week two

Date	Ozone average (Ppbv)	Ozone Average (Ppmv)
3/12/07	23.30	0.0233 ppm
3/13/07	14.56	0.0145 ppm
3/14/07	22.60	0.0226 ppm
3/15/07	26.08	0.0260 ppm
3/16/07	19.26	0.0192 ppm

Table 5

National Ambient Air Quality Standards (2007). Environmental Protection Agency.

National Ambient Air Quality Standards

Pollutant	**Primary Stds.**	**Averaging Times**	**Secondary Stds.**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour	None
	35 ppm (40 mg/m^3)	1-hour	None
Lead	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	Revoked	Annual (Arith. Mean)	
	150 $\mu g/m^3$	24-hour	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (Arith. Mean)	Same as Primary
	35 $\mu g/m^3$	24-hour	
Ozone	0.08 ppm	8-hour	Same as Primary
	0.12 ppm	1-hour (Applies only in limited areas)	Same as Primary
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	-------
	0.14 ppm	24-hour	-------
	-------	3-hour	0.5 ppm (1300 $\mu g/m^3$)

The EPA list of Criteria air pollutants.

Table 6

Wind speed measurements at Paula Mojica Community School, 2007.

Measured at Miles per Hour (MPH)

A Nielsen- Kellerman Kestrel 2000 anemometer was used.

Week one

Date	**Wind speed average (MPH)**	**Maximum wind speed (MPH)**
3/5/07	4.2	8.6
3/6/07	4.2	8.3
3/7/07	N/A	N/A
3/8/07	4.1	8.6
3/9/07	4.3	9.0
Average total:	4.2	8.6

Week two

Date	**Wind speed average (MPH)**	**Maximum wind speed (MPH)**
3/12/07	4.3	8.9
3/13/07	4.2	8.0
3/14/07	5.0	9.0
3/15/07	4.1	8.7
3/16/07	4.2	8.3
Average total:	4.36	8.58

Two week average totals*: 4.28* *8.59*

Table 7

Ozone measured data deviation from the National Ambient Air Quality Standards (NAAQS).

Primary ozone standard = 0.08 ppm/ 8-hour

(0.08 ppmv – ozone average = Difference from primary ozone standard)

Week one

Date	Ozone average (Ppmv)	Difference from primary ozone standard (ppmv)
3/5/07	0.01845 ppm	0.062 ppm
3/6/07	0.01486 ppm	0.066 ppm
3/7/07	N/A	N/A
3/8/07	0.02103 ppm	0.060 ppm
3/9/07	0.02117 ppm	0.060 ppm
Average total:	0.018 ppm	0.062 ppm

Week two

Date	Ozone average (Ppmv)	Difference from primary ozone standard (ppmv)
3/12/07	0.0233 ppm	0.06 ppm
3/13/07	0.0145 ppm	0.07 ppm
3/14/07	0.0226 ppm	0.06 ppm
3/15/07	0.0260 ppm	0.06 ppm
3/16/07	0.0192 ppm	0.07 ppm
Average total:	0.021 ppm	0.064 ppm

Table 8

Average daily temperature measured at Paula Mojica Community Public School during ozone data collection in degrees Farenheight. (°F)

Week one

Date	Average high (°F)	Average low (°F)	Mean (°F)
3/5/07	85°	61°	73°
3/6/07	85°	61°	73°
3/7/07	N/A	N/A	N/A
3/8/07	85°	61°	73°
3/9/07	85°	61°	73°
Average total:	**85°**	**61°**	**73°**

Week two

Date	Average high (°F)	Average low (°F)	Mean (°F)
3/12/07	86°	61°	73°
3/13/07	86°	61°	73°
3/14/07	86°	61°	74°
3/15/07	86°	61°	74°
3/16/07	86°	61°	74°
Average total:	**86°**	**61°**	**73.6°**

Table 9

Calculated percentages from data obtained from the student's questionnaire totals.

(Table 3) N=133.

Diagnosed with asthma:	45/133 x 100 = 33.8 %
No diagnosed with asthma:	88/133 x 100 = 66.16%
Receives treatment for asthma:	27/133 x100 = 20.30%
Does not receive treatment for asthma:	101/133 x100 = 75.93%
Use medication for asthma:	28/133 x 100= 21.05%
Do not use medication for asthma:	100/133 x 100= 75.18 %
Diagnosed with asthma & receive treatment:	20.30/33.8 x 100 = 60 %
Diagnosed with asthma & receive medications:	21.05/33.8 x 100 = 62.27 %
Diagnosed with asthma & do not receive treatment	100%-60% = 40%
Diagnosed with asthma & do not receive medications	100%- 62.27% = 37.73 %

Table 10

Student's residency distribution in relation with asthma condition.

Calculated percentages from data derived from the student's questionnaires from table 3. N=133.

Live in **urban** area and **are** asthmatic:	37 ÷ 133 X 100 = 27.8%
Live in **urban** area and are **not** asthmatic:	73 ÷ 133 X 100 = 54.8%
Live in **rural** area and **are** asthmatic:	10 ÷133 X 100 = 7.51%
Live in **rural** area and are **not** asthmatic:	12 ÷133 X 100 = 9.02%
Live in **industrial** area and **are** asthmatic:	0
Live in **industrial** area and are **not** asthmatic:	1 ÷133 X100 = 0.75 %

FIGURES

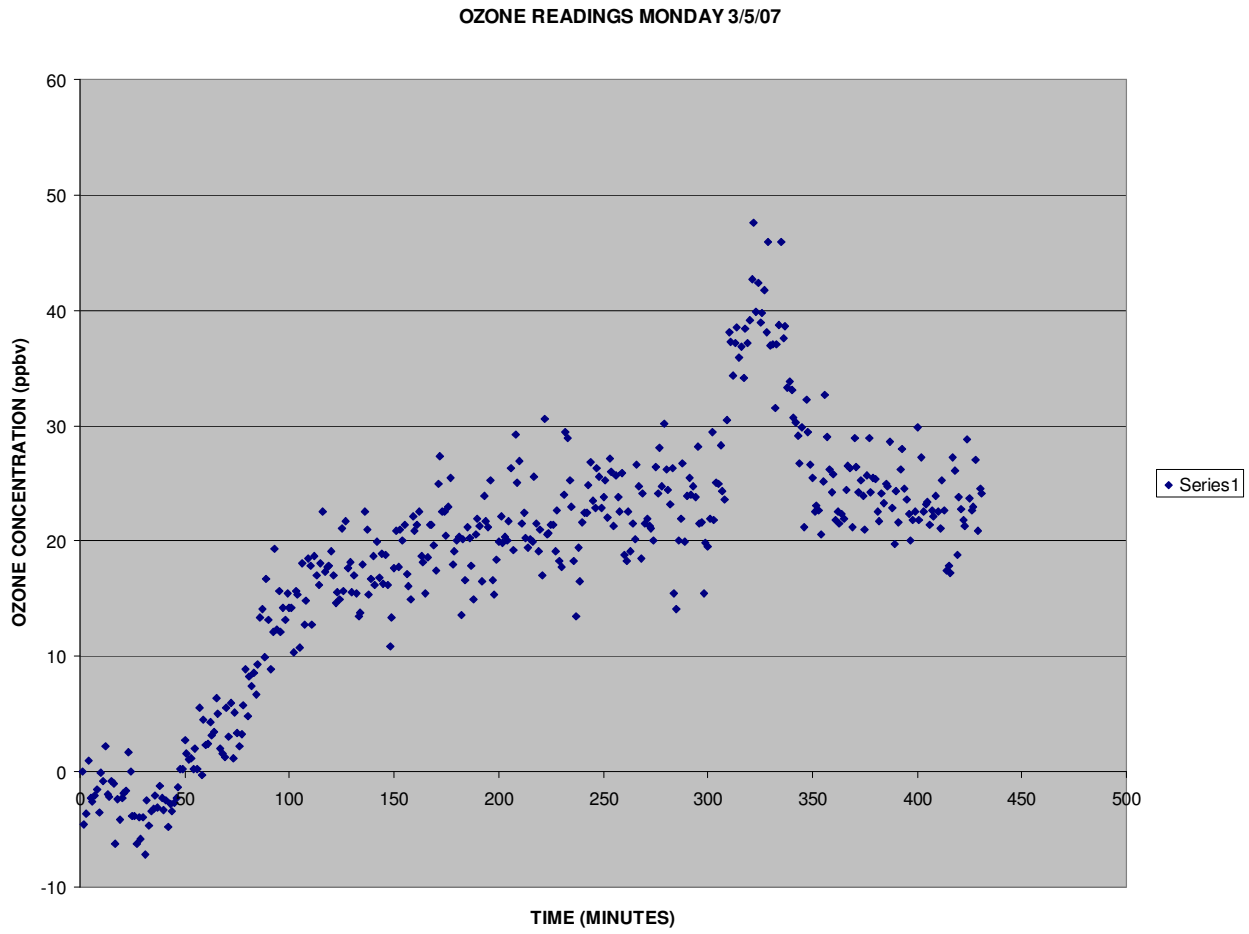


Figure 1. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=452). All measurements are well below the NAAQS for ozone = 80 ppbv.

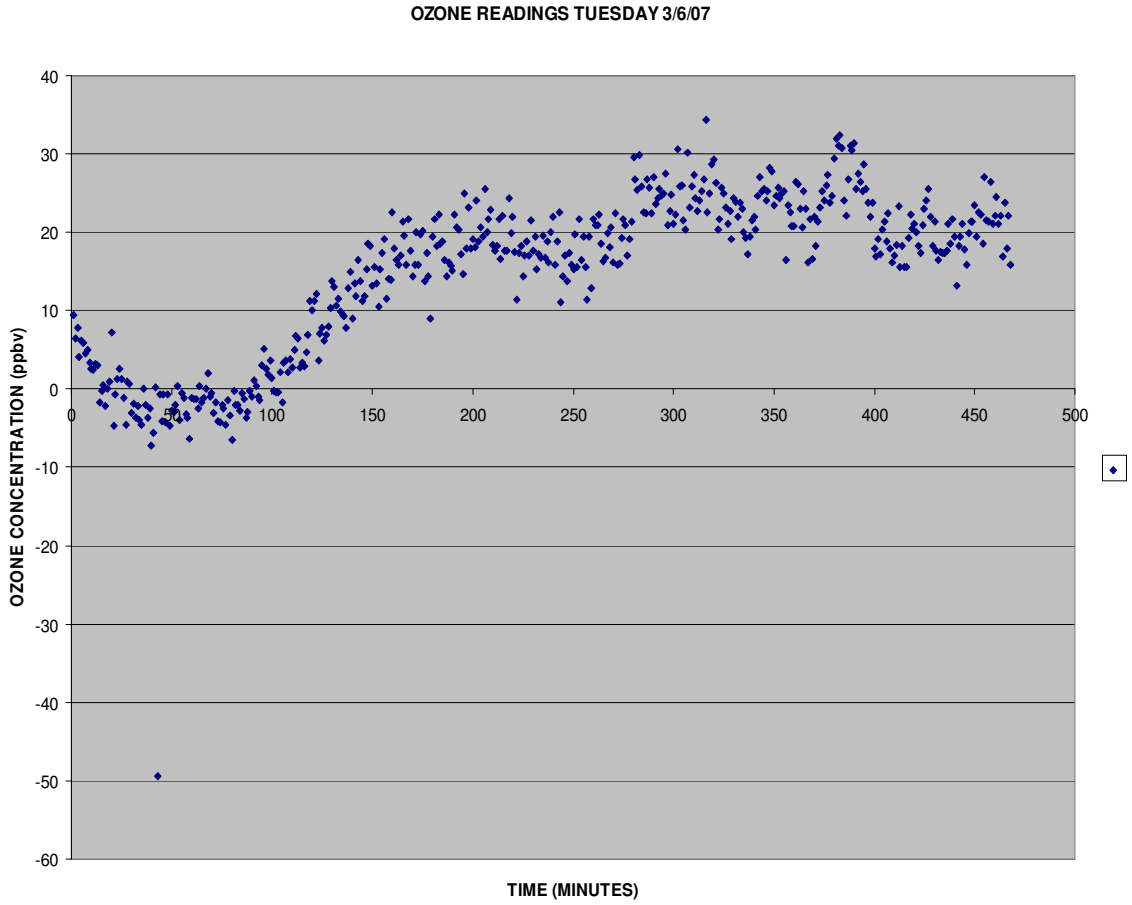


Figure 2. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=466). All measurements are well below the NAAQS for ozone = 80 ppbv.

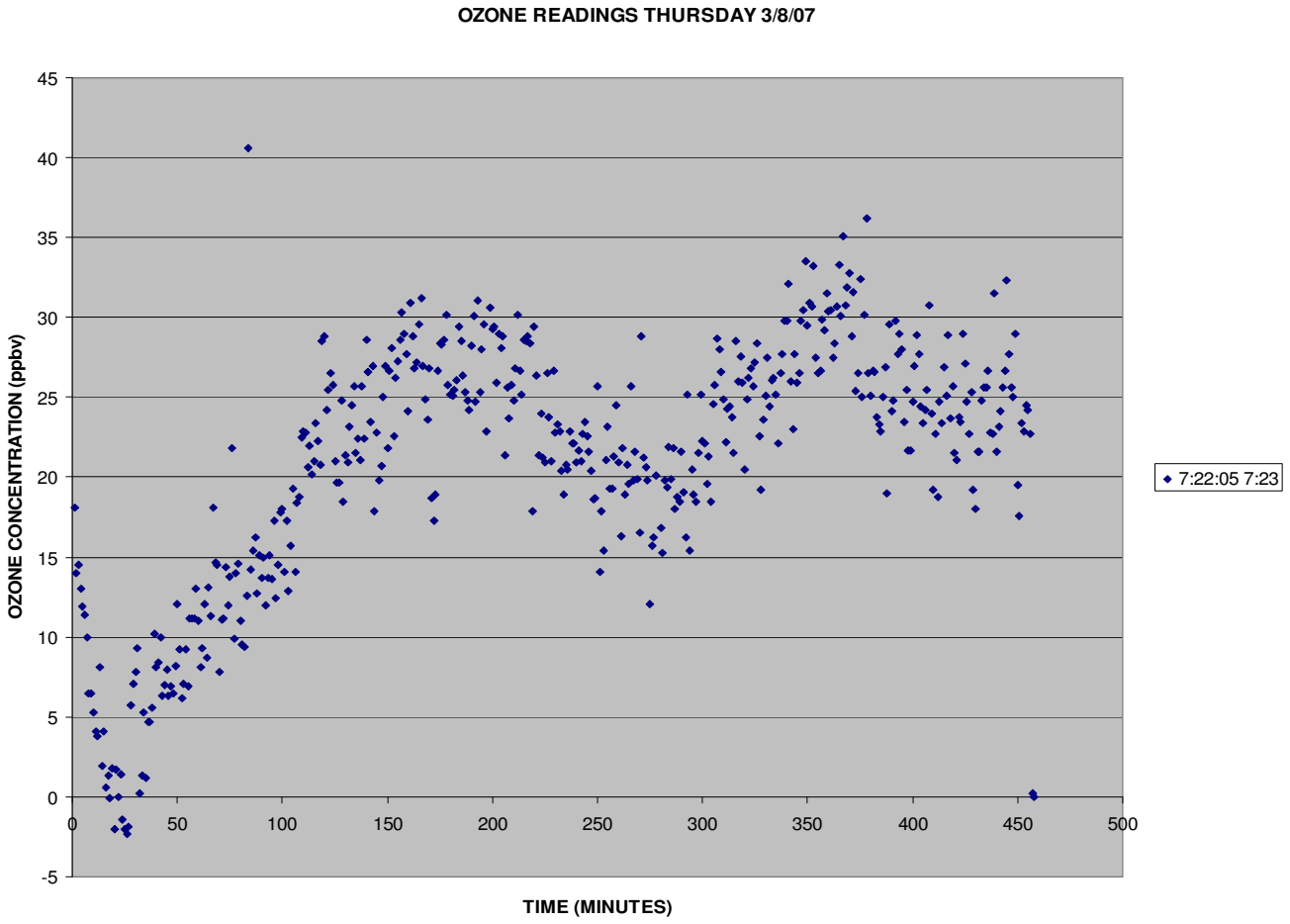


Figure 3. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=452). All measurements are well below the NAAQS for ozone = 80 ppbv.

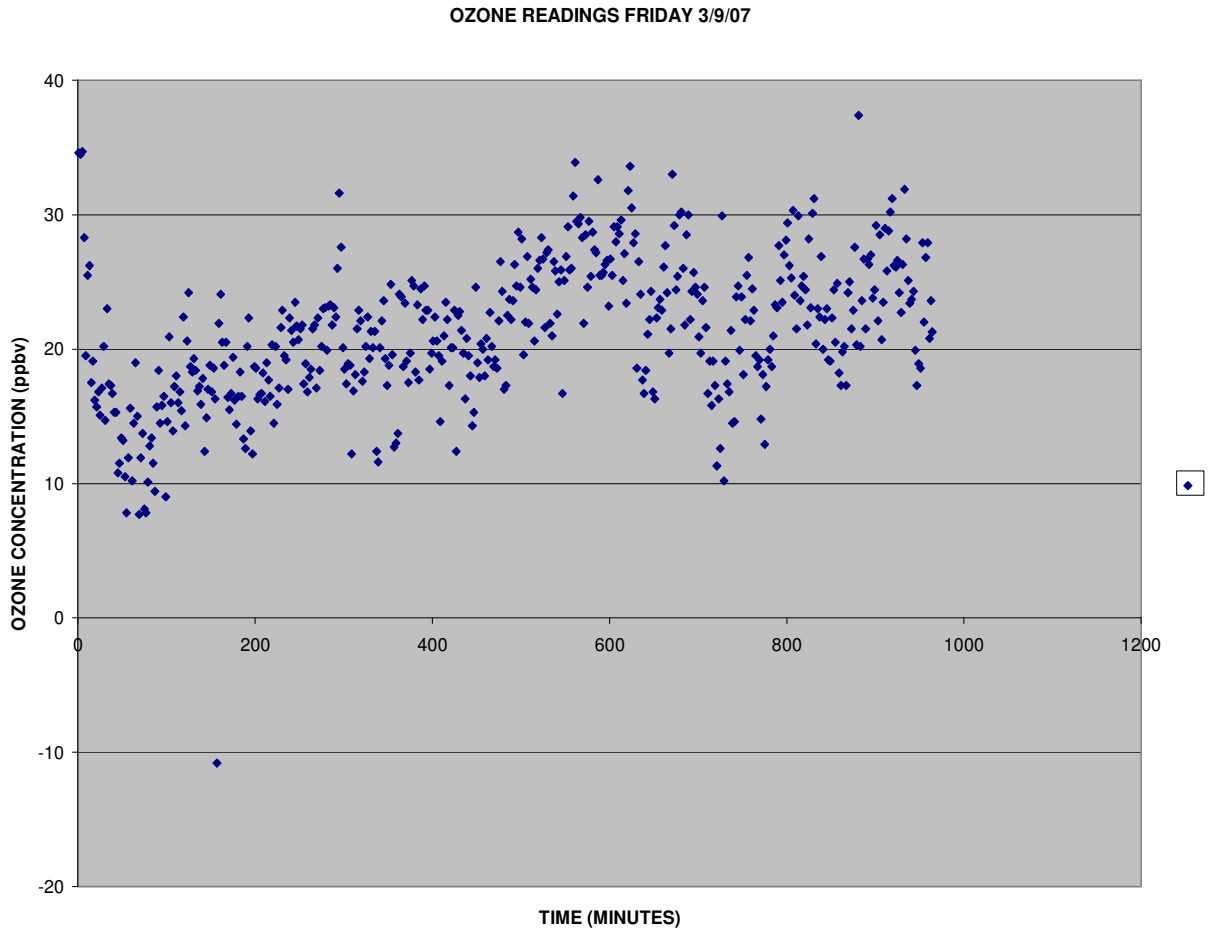


Figure 4. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=471). All measurements are well below the NAAQS for ozone = 80 ppbv.

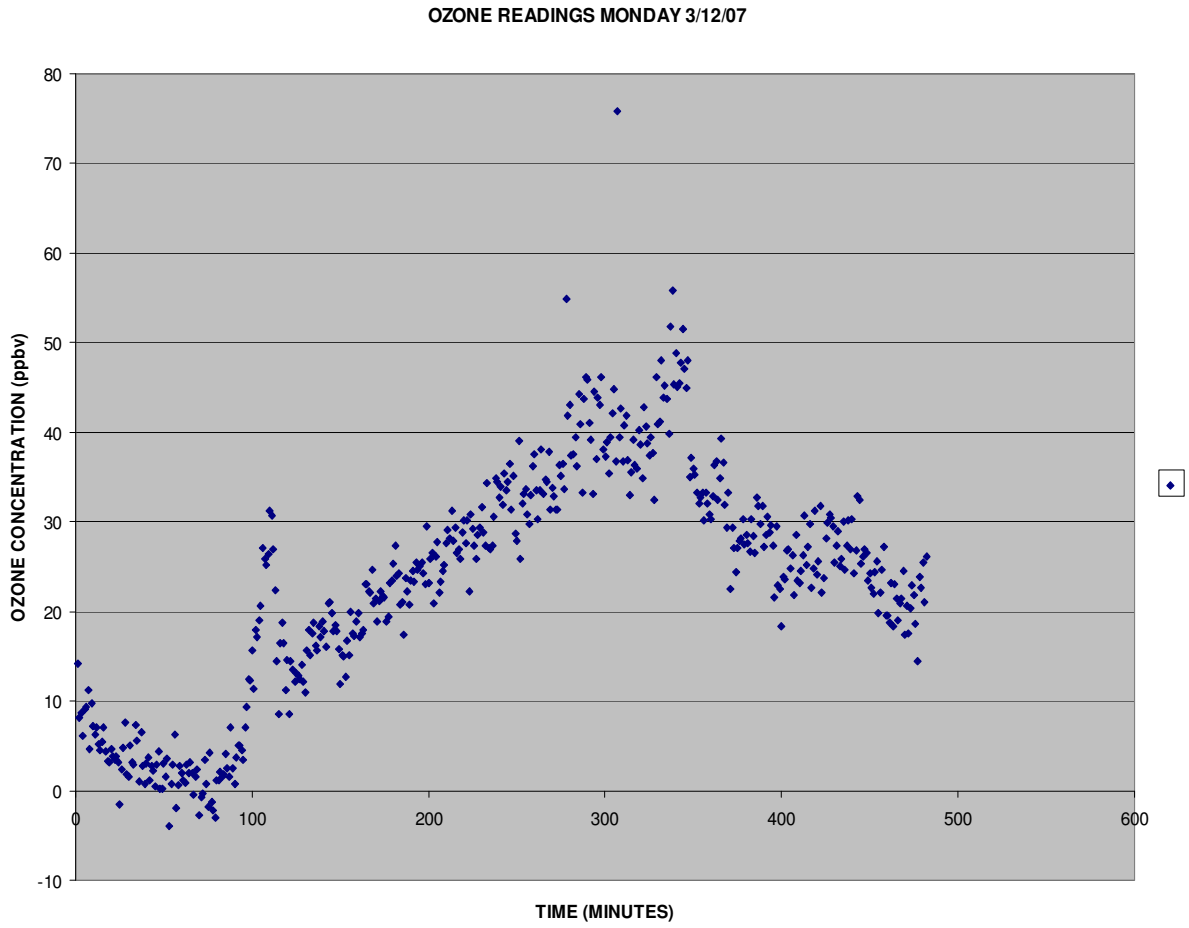


Figure 5. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=480). All measurements are well below the NAAQS for ozone = 80 ppbv.

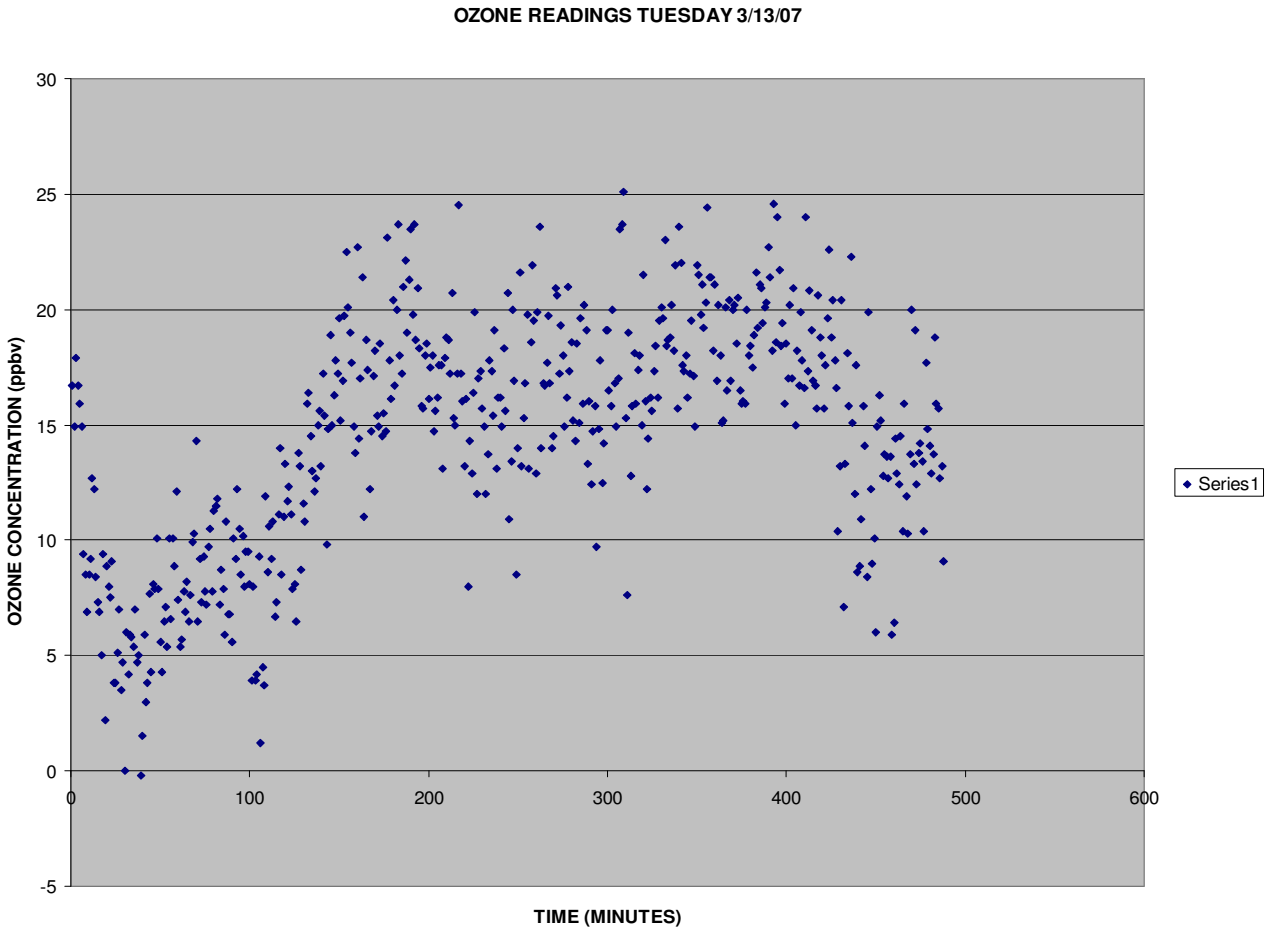


Figure 6. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=499). All measurements are well below the NAAQS for ozone = 80 ppbv.

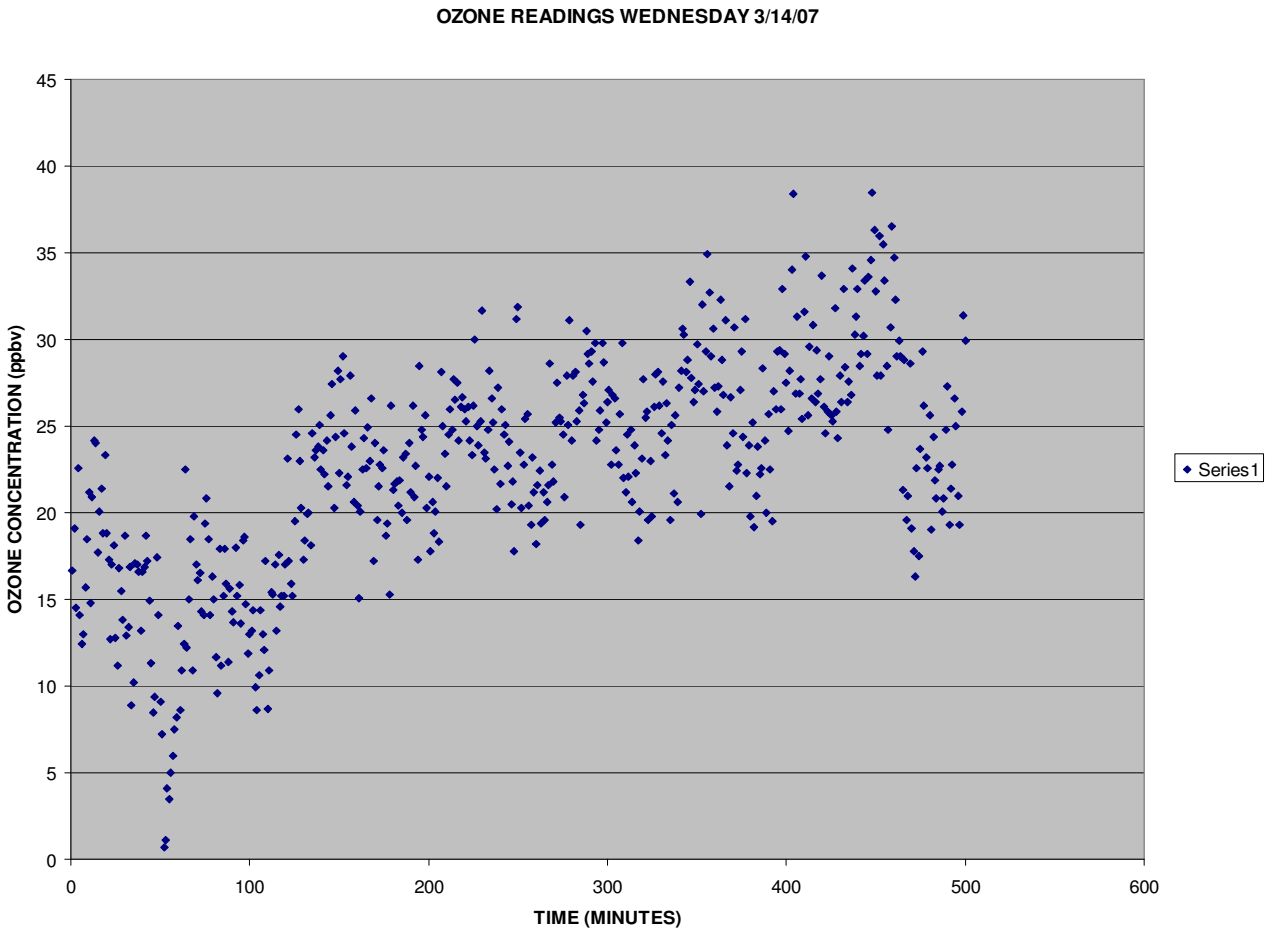


Figure 7. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=499). All measurements are well below the NAAQS for ozone = 80 ppbv.

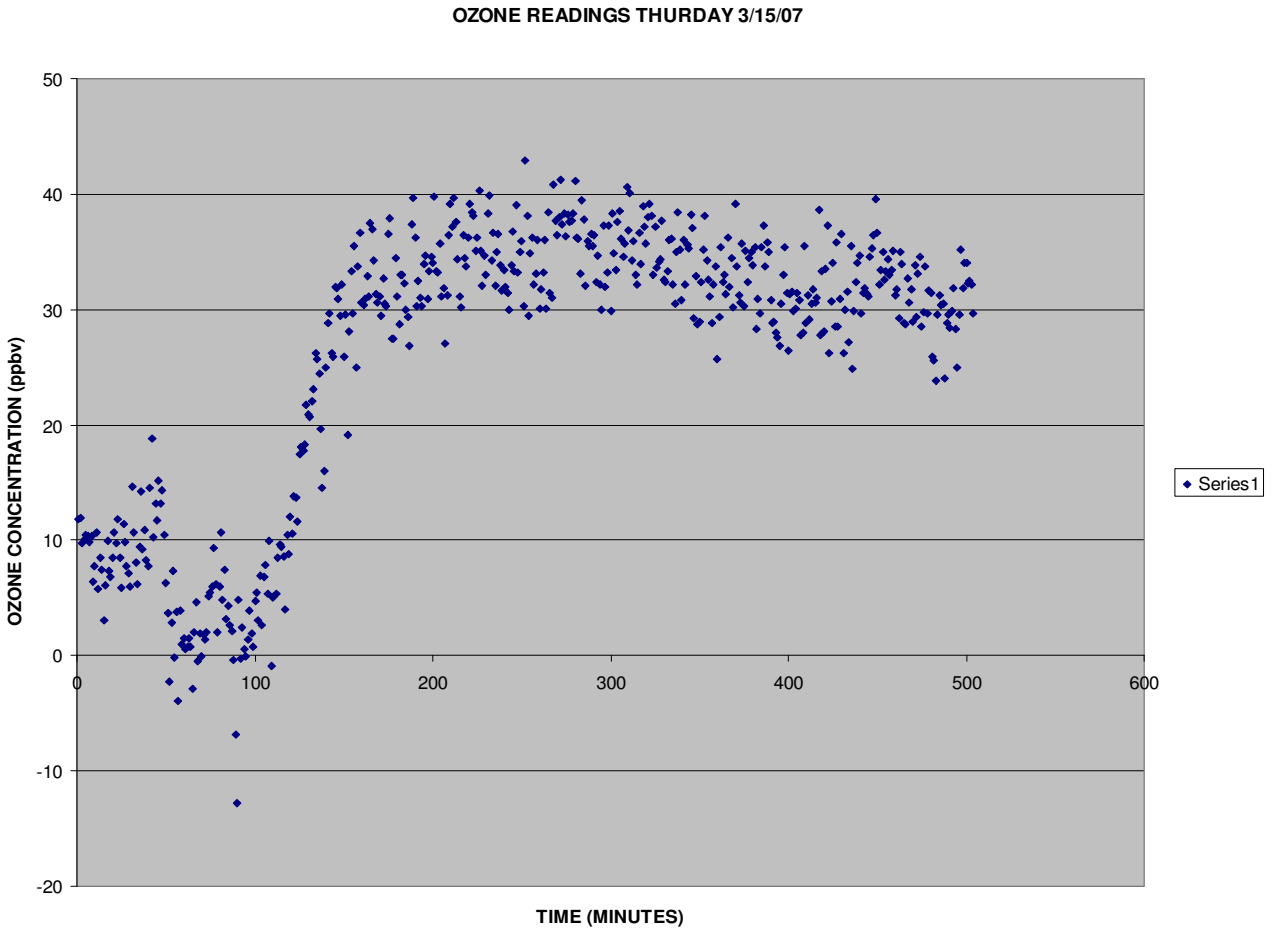


Figure 8. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=502). All measurements are well below the NAAQS for ozone = 80 ppbv.

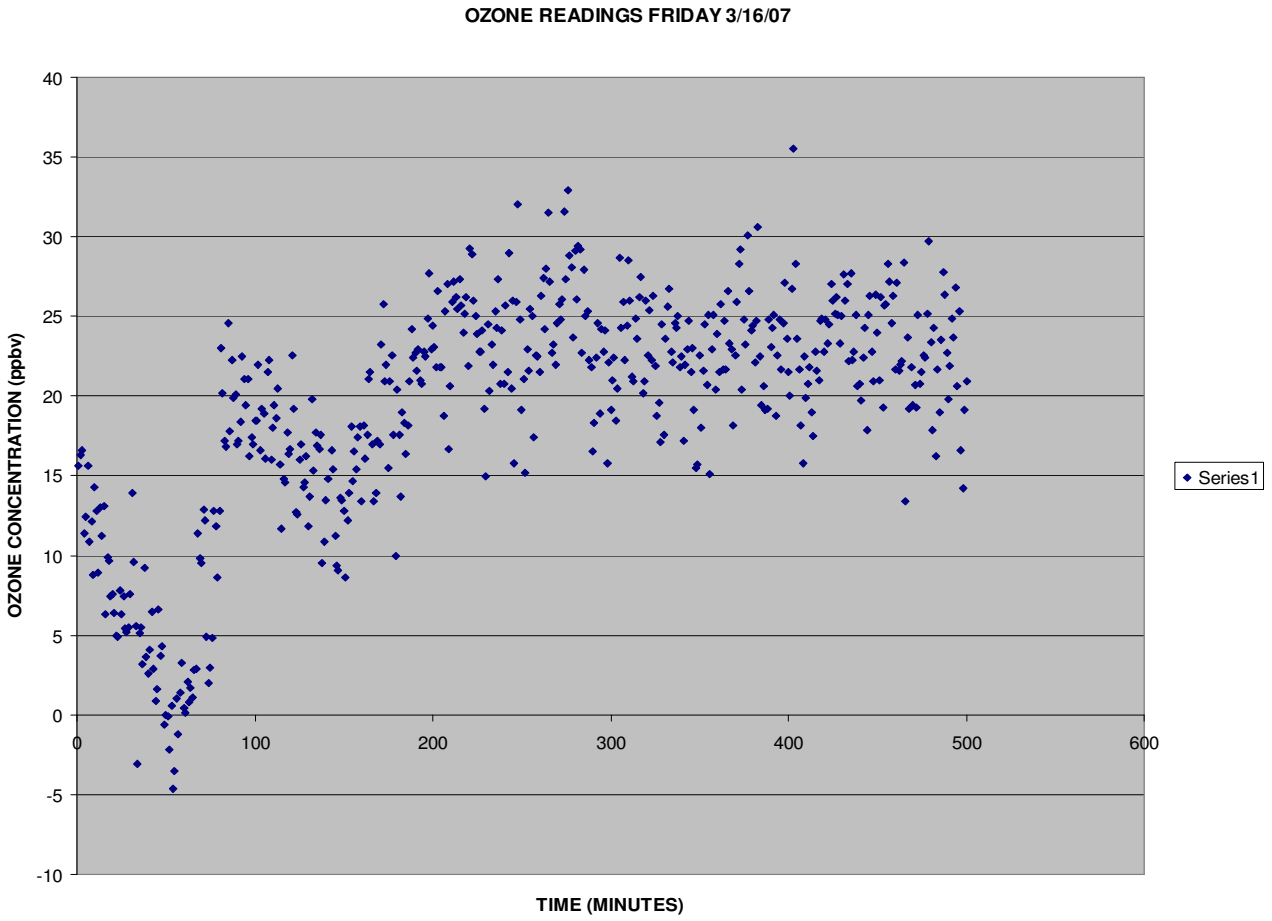
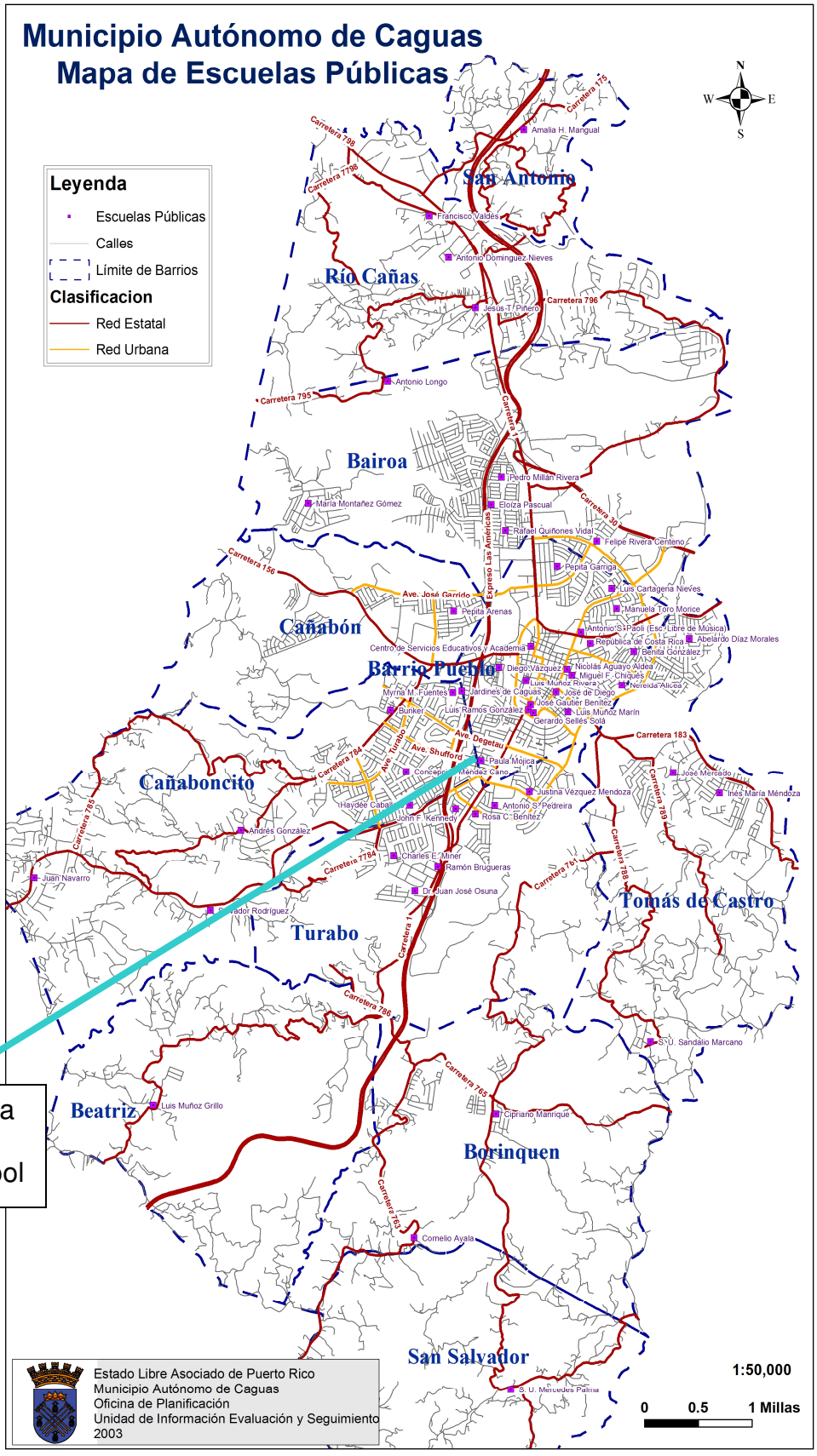


Figure 9. Distribution of ground level ozone readings during an 8 hour sampling event. Each point represents a data averaging of 6 measurements per minute (n=497). All measurements are well below the NAAQS for ozone = 80 ppbv.

APPENDIX

APPENDIX 1

Map of location of Public Schools in the Caguas region of Puerto Rico with the location of Paula Mojica Community Public School shown.



Paula Mojica Community Public School

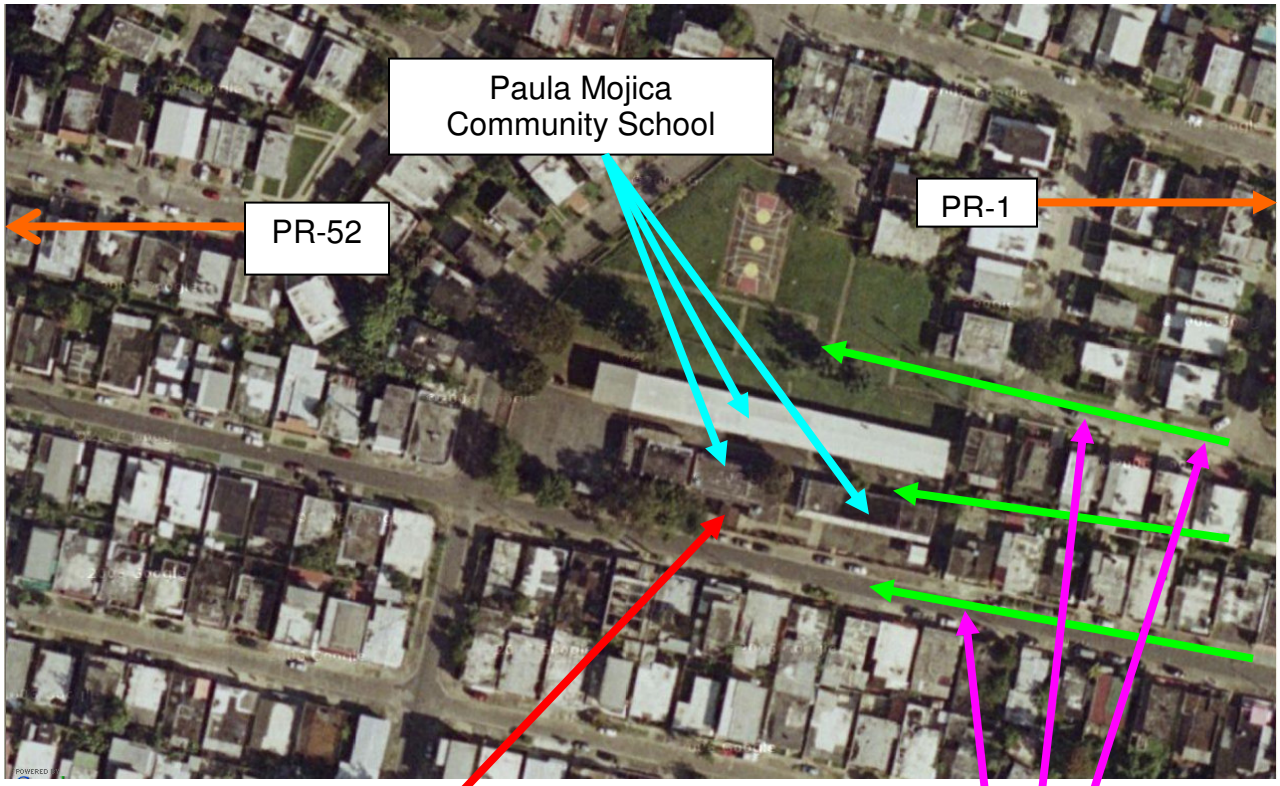
APPENDIX 2

Satellite photograph of the location of Paula Mojica Community School nested between the two main roadways in the Caguas region of Puerto Rico.


PR-52
Paula Mojica Community Public School
PR-1

APPENDIX 3

Satellite photograph of the location of the ozone monitor at Paula Mojica Community Public School with the wind direction shown.


Paula Mojica
Community School
PR-52
PR-1
Ozone monitor
location
Wind direction on
westerly track
4.2 MPH average

APPENDIX 4

Questionnaire used for student's asthma data acquisition (n= 133).

Universidad Metropolitana
Escuela de Asuntos Ambientales
Sistema Universitario Ana G. Méndez

A quien pueda interesar:

La presente es para solicitar su cooperación en la recopilación de información como parte de un estudio de asma en el pueblo de Caguas. Dicho estudio es realizado por el Sr. Ángel F. Villalba Galán y la Universidad Metropolitana. Necesitamos información para documentar la incidencia de asma en los barrios y conocer los casos diagnosticados de asma en la población escolar a nivel elemental en Caguas. La información que se recopile en este cuestionario es confidencial y no requiere datos personales familiares ni del estudiante. Agradeceremos si toma unos minutos para contestar las preguntas a continuación. Esperamos que la información ayude a mejorar la calidad de vida y el bienestar social en el municipio de Caguas.

Muchas gracias por su atención.

CUESTIONARIO

Información básica de la familia:

1) Barrio donde reside:_____

2) ¿Donde se encuentra su vivienda? (escoger solo una)

____ Zona industrial ____ Zona urbana _____Zona Rural

Perfil de asma del estudiante de escuela elemental

3) Sexo del estudiante: Femenino_____ Masculino_____

4) Edad:____

5) ¿Ha sido diagnosticado como paciente de asma por un medico?

SI____ NO_____ ¿Por cuánto tiempo?_____

6) ¿Recibe algún tratamiento? SI____ No_____ SI responde SI, indique cual_____

7) ¿Utiliza algún medicamento? Si____ No_____Si responde SI, indique cual_____

8) ¿Qué cree que provoca el asma de su hijo(a)? Escoja todas las alternativas pertinentes

___Polvo ____Medicamentos ___Polen _____Contaminación del Aire ___Moho

___Insecticidas _____Humedad ____Productos de limpieza _____Humo del cigarrillo

____Otros, (Mencione) _____

APPENDIX 5

Informative letter provided to school parents pertaining to the experiment, the location of the ozone measuring equipment on school grounds and its purpose.

UNIVERSIDAD METROPOLITANA
ESCUELA DE ASUNTOS AMBIENTALES

2 DE MARZO 2007

Estimados padres/ custodio legal:

Saludos, Mi nombre es Ángel F Villalba Galán y soy estudiante de Maestría de la Escuela de Asuntos Ambientales de la Universidad Metropolitana. Por este medio les deseo informar que durante la semana del **5 al 9 de marzo del 2007** voy a estar llevando a cabo un estudio científico en la escuela de la Comunidad Paula Mojica. Parte del estudio comprende **un análisis del aire** que recibe la escuela de la carretera # 1 durante el horario escolar entre las horas de 7am hasta las 3 PM. Para lograr este propósito se va a ubicar en la escuela Paula Mojica un instrumento científico con la intención de medir los niveles de **ozono** que se puedan encontrar en el aire. Este instrumento es aproximadamente del tamaño de una maquina de "videotape" color azul y se va a ubicar en la parte exterior de la oficina de la directora dentro de los predios de la escuela y frente a la calle. Lo único que hace este instrumento es analizar muestras de aire, es electrónico y no representa ningún riesgo a los estudiantes o persona alguna.

Este estudio cuenta con la autorización del Departamento de Educación de Puerto Rico

El propósito de esta carta es informar a los padres/ custodios legales sobre el instrumento científico que muchos van a ver al llevar y recoger sus niños a la escuela.

En caso de tener alguna duda al respecto se puede comunicar al:
(787) 743-7979. Ext., 4279 entre las 9:00 AM y las 2:00 PM.

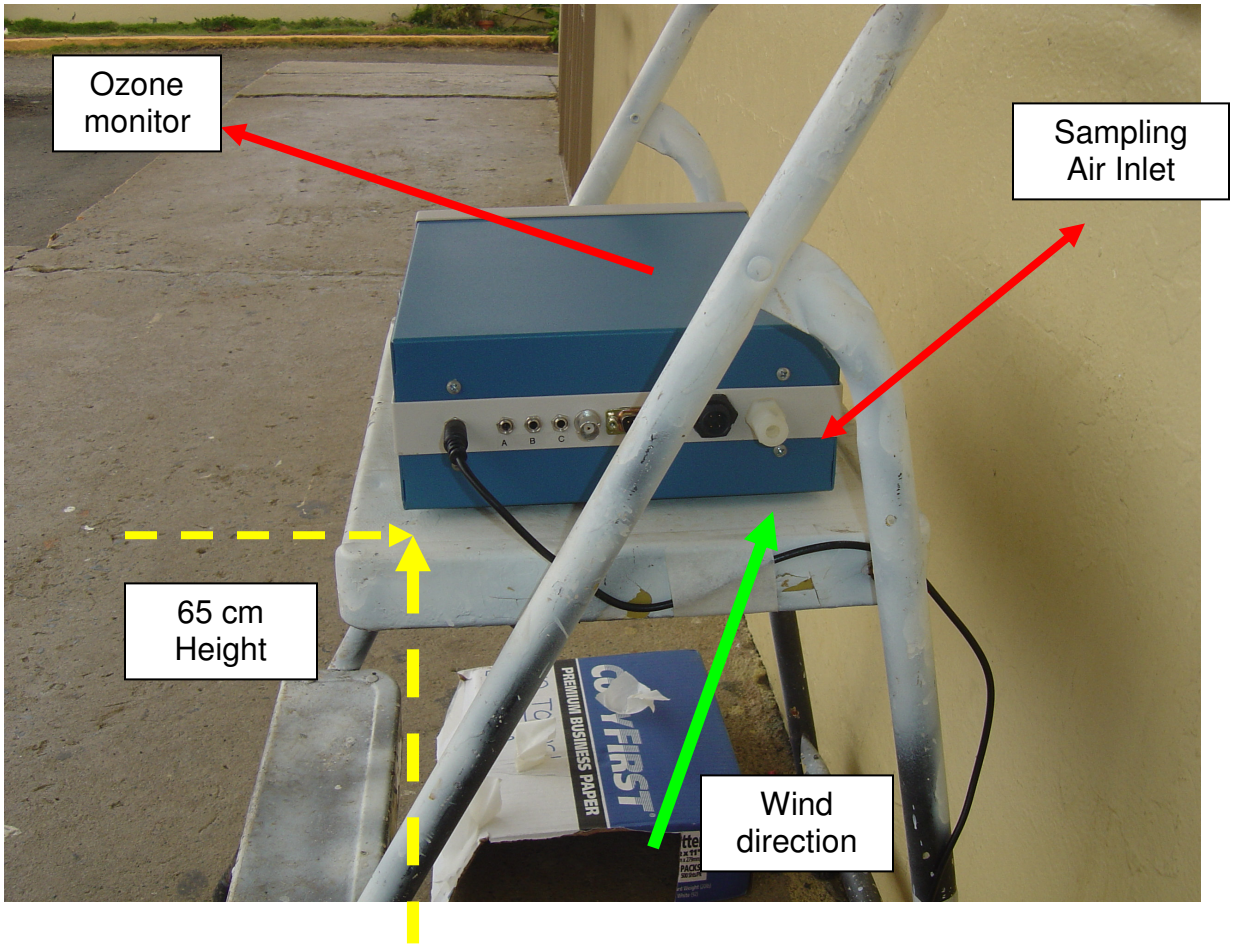
Atentamente

_____

Ángel F. Villalba Galán, REM

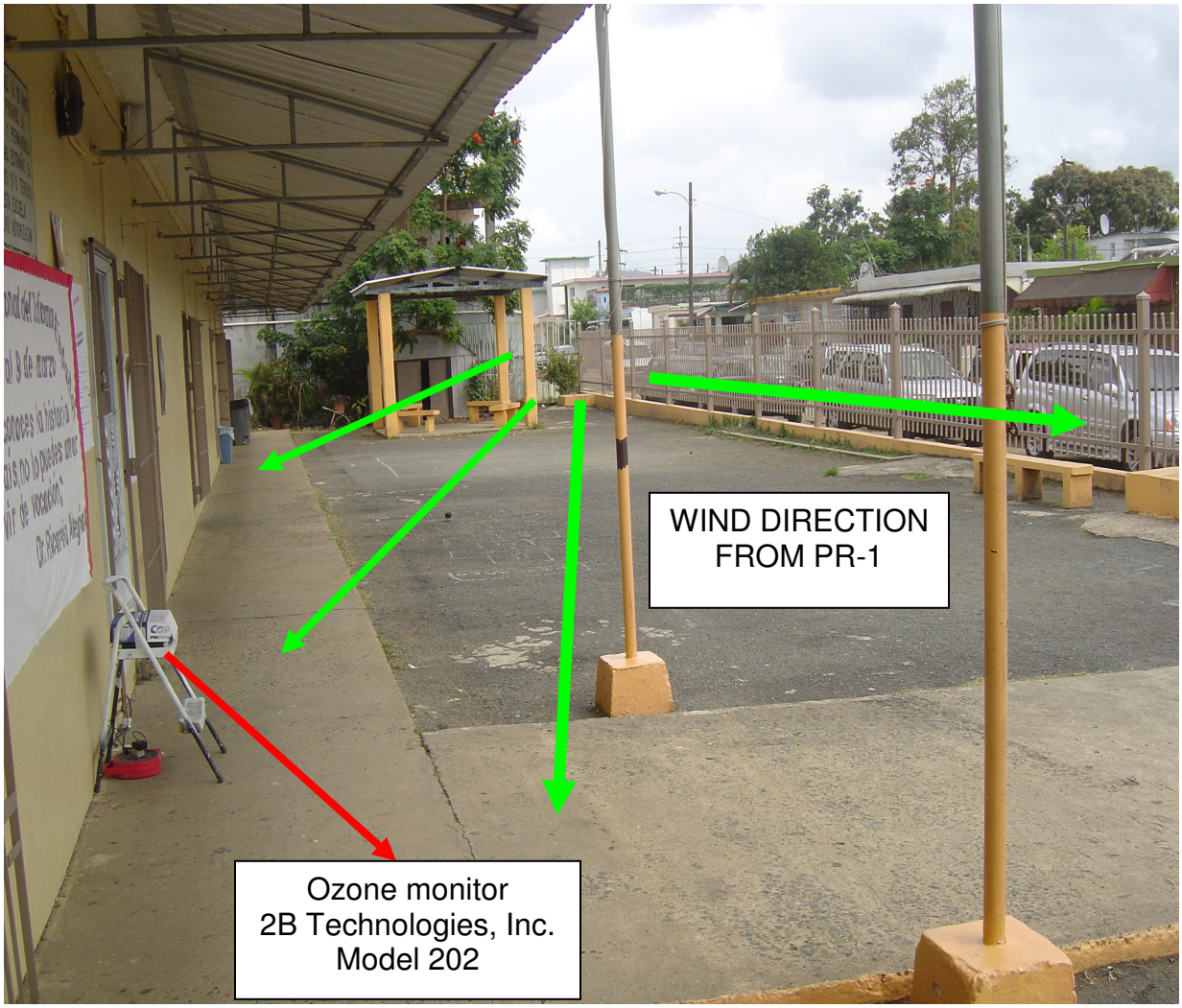
APPENDIX 6

Location and positioning of the ozone monitor at Paula Mojica Community Public School for data acquisition purposes.


Ozone monitor
Sampling Air Inlet
65 cm Height
Wind direction
PREMIUM BUSINESS PAPER

APPENDIX 7

Wind direction flow towards the ozone monitor located in front of Paula Mojica Community Public School. Constant wind flow towards the school was noticeable.


WIND DIRECTION
FROM PR-1
Ozone monitor
2B Technologies, Inc.
Model 202

APPENDIX 8

Ozone monitor's ground clearance and location at

Paula Mojica Community Public School.


LA LEY 30 DEL 16 DE MAYO
DE 1972 PROHIBE LA
PENETRACION Y PERMANENCIA
DE PERSONAS EXTRAÑAS EN
LOS EDIFICIOS Y/O TERRENOS
DE ESTA ESCUELA
SIN PREVIA AUTORIZACION
ENGLISH
WEEK
CELEBRATION
MARCH
19-23
65cm

APPENDIX 9

Ozone monitor with cardboard cover to keep it from prying eyes.


conoces la historia
país, no lo puedes amar
rvir de vocación."
Dr. Ricardo Alegría

APPENDIX 10

Localization of Ozone Monitor in front of Paula Mojica Community Public School.


ESCUELA ELEMENTAL
PAULA MOJICA
Localization of Ozone Monitor

APPENDIX 11

IRB-AGMUS Parental consent to participate in the research. Spanish version

FORMA DE CONSENTIMIENTO
UNIVERSIDAD METROPOLITANA
ESCUELA DE ASUNTOS AMBIENTALES

TESIS DE MAESTRIA EN GERENCIA AMBIENTAL EN AVALUO Y MANEJO DE RIESGO AMBIENTAL

Febrero 15, 2007 Fecha de expiración: Mayo 20,2007

Estimado padre/ custodio legal:

Saludos! Usted ha sido invitado a participar en un estudio de investigación acerca del **riesgo a la exposición de ozono en niños de una escuela elemental en la región geográfica de alta densidad de asma en Caguas, PR.** Esta investigación esta a cargo del Sr. Ángel F. Villalba Galán, estudiante graduado de la Escuela de Asuntos Ambientales de la Universidad Metropolita de Puerto Rico.

Usted ha sido seleccionado a participar de esta investigación debido a la localización de la escuela de la comunidad Paula Mojica cerca de una carretera primaria de alto nivel de trafico vehicular en Caguas y la correspondiente asistencia de su hijo (a) (s) a esta escuela. El propósito de la investigación envuelve la medición del ozono a nivel del suelo que se encuentra en los predios de la escuela y la correcta determinación del número de estudiantes que padecen de asma pediátrica. Se espera poder correlacionar la presencia de ozono con los ataques de asma que ocurren en la escuela.

Se espera que los padres de aproximadamente unos 400 niños que atienden la escuela elemental Paula Mojica accedan a participar de esta investigación.

Si acepta participar en esta investigación, a usted se le va a solicitar que conteste un cuestionario que se encuentra adjunto a esta forma de consentimiento. Esta forma de consentimiento luego de contestada va a ser recogida por personal de la escuela Paula Mojica para luego ser transferida al investigador principal. La participación en este estudio toma entre 3 a 5 minutos de su tiempo.

La participación es completamente anónima.

Riesgos y beneficios

Se estima que su participación en esta investigación conlleva riesgos mínimos. Los posibles riesgos mínimos pueden estar relacionados con el anonimato de los participantes aunque su identidad y la de su (s) niños van a ser protegida.

Confidencialidad

Toda la información o data recopilada va a ser manejada en estricta confidencialidad. Esta forma de consentimiento va a ser recogida junto al cuestionario y entregada al investigador principal mientras que la carta de presentación quedara bajo posesión de la directora de la escuela Paula Mojica como evidencia de participación en la investigación según lo establecido por el Departamento de Educación de Puerto Rico (DEPR). El investigador no tiene ni va a tener acceso a los nombres de los estudiantes ni de los padres o custodios legales de los mismos en ningún momento. Solamente la directora de la escuela y la trabajadora social tienen acceso a las identidades de los alumnos de la escuela Paula Mojica.

El Sr. Ángel F. Villalba Galán, investigador principal y la Dra. Teresa Lipsett, Directora de Tesis van a ser las únicas personas con acceso a la información recopilada que no incluye la identidad

de los alumnos de la escuela Paula Mojica. Esta data va a ser almacenada en un archivo por un periodo de cinco (5) anos según lo requiere la ley luego de concluida la investigación.
Luego de pasados 5 años, los documentos son triturados y destruidos.

Derechos

Si luego de haber leído este documento usted decide participar de la investigación, por favor comprenda que su participación es una voluntaria y usted tiene el derecho de desistir de participar en cualquier momento sin sufrir penalidad alguna. También usted tiene el derecho de no tener que contestar ninguna pregunta en particular. Usted tiene derecho a recibir copia de este documento. Ni usted el participante va a recibir ningún tipo de compensación por participar de esta investigación. Ninguna compensación ha sido prometida para daños supuestos o sufridos asociados a esta investigación.

Si usted tiene alguna otra pregunta o desea más información acerca de esta investigación, se puede comunicar:

Ángel F. Villalba Galán
Principal Investigador
(787) 306-5125; (787) 743-7979 Ext.4279
Manta8@prtc.net

Dr. Teresa Lipsett, PhD.
Directora de tesis
(787) 743-7979. Ext. 4267
ut_lipsett@SUAGM.EDU

Si tiene alguna otra pregunta acerca de sus derechos como participante o si tiene alguna queja relacionada a su participación se puede comunicar con:

SUAGM Compliance Office at
(787) 751-3120
cumplimiento@suagm.edu

La firma de este documento significa que usted ha decidido participar de esta investigación luego de haber leído el contenido de esta forma de consentimiento.

_____	_____	_____
Nombre del participante Padre/ madre/ encargado	Firma	Fecha

YO atesto al contenido de este documento en el cual he explicado los riesgos y beneficios de este estudio de investigación.

Ángel F. Villalba Galán

_____	_____	_____
Nombre del investigador	Firma	Fecha

APPENDIX 12

IRB-AGMUS Parental consent to participate in the research. English version

INFORMED CONSENT
Universidad Metropolitana
School of Environmental Affairs

Masters Degree Thesis in Environmental Risk Assessment & Management

February 15, 2007 Expiration date: May 20, 2007

Esteem parent/ legal guardian:

Greetings! You have been invited to participate in a research about **ozone exposure on elementary school children in the geographical asthma prone region of Caguas, Puerto Rico**. This research is in charge of Mr. Angel F. Villalba Galan, a graduate student from the faculty of The School of Environmental Affairs at Universidad Metropolitana in Puerto Rico.

You have been selected to participate in this research because of the location of the *Escuela de la Comunidad* Paula Mojica to a heavy traffic primary road in Caguas, PR and the attending of your child (ren) to this school. The purpose of the research involves the measuring of ground level ozone at the school and the proper identification of the number of students that suffer from pediatric asthma. It is hoped that a correlation between ozone and asthma attacks at the school is found by this research.

It is expected that the parents of approximately 400 students at Paula Mojica elementary school will volunteer to participate in this research.

If you accept to participate in this research, you will be asked to complete a questionnaire that is attached to this Informed Consent letter. This consent letter will then be collected by Paula Mojica school personnel and transferred to the primary investigator. Participating in this study will only take between 2 to 5 minutes of your time.

Participation on this research is completely anonymous.

Risks and benefits

It is estimated that your participation in this investigation will have minimum risks. The possible risks might be related to the anonymity of the participants but your identity and the identity of your child (ren) will be protected.

The awaited benefit from this research is that information pertaining to the ozone presence in school property might be obtained and its consequences on asthmatic students can be calculated.

Confidentiality

All of the information or data will be managed confidentially. This Informed consent letter will be collected for the researcher together with the attached questionnaire while the presentation letter will remain on school records as proof of participation in the research as required by the Puerto Rico Department of Education. The researcher does not have access to the student name at any time. Only the school director and the social worker have access to the student's names.

Mr. Angel F. Villalba Galan, primary investigator and **Dra. Teresa Lipsset, PhD**. Thesis director will be the only ones with access to the raw data that does not include the students names. This data will be stored in a file cabinet for a period of five (5) years as required by law after the research has concluded. After this period, the documents will be destroyed in a paper shredder.

Rights

If you have read this document and have decided to participate, please understand that your participation is completely voluntary and that you have the right to abstain from participating or you can retire from the study at any moment, without any penalty. You also have the right of not answering any particular question. Also, you have the right of receiving a copy of this document. You will not receive any compensation for participating in this investigation. No compensation has been promised for alleged damages associated to this investigation.
If you have any questions or want to have more information about this research, please contact:

Ángel F. Villalba Galán
Principal Investigator
(787) 306-5125; (787) 743-7979. Ext.4279
Manta8@prtc.net

Dr. Teresa Lipsett, PhD.
Thesis Director
(787) 743-7979. Ext. 4267
ut_lipsett@SUAGM.EDU

If you have any questions about your rights as a participant or any complain related to your participation in this study you can contact:

SUAGM Compliance Office at
(787) 751-3120
cumplimiento@suagm.edu

If you Sing this document it means that you have decided to participate after you have read the information presented in this informed consent.

_____	_____	_____
Name of the participant	Signature	Date

I attest to the contents of this Informed Consent letter and I have explained the risks and benefits of the study.

_____	_____	_____
Name of the Investigator	Signature	Date

APPENDIX 13

Parental consent form. PRDOE & school copy. Spanish version

UNIVERSIDAD METROPOLITANA
ESCUELA DE ASUNTOS AMBIENTALES

FORMA DE CONSENTIMIENTO PARA ESTUDIO DE TESIS DE MAESTRIA EN AVALUO Y MANEJO DE RIESGO AMBIENTAL

15 de Febrero 2007 Fecha de expiración: Mayo 20, 2007

Estimado padre/ madre/ custodio legal:

! Saludos! Mi nombre es **Ángel F. Villalba Galán** y soy estudiante de maestría de la Escuela de Asuntos Ambientales de la Universidad Metropolitana de Puerto Rico. Por este medio deseo solicitar su ayuda para poder llevar a cabo un estudio científico que puede beneficiar a su(s) hijo(s) o hija(s) mejorando la calidad del aire en la escuela Paula Mojica y de esta forma lograr disminuir episodios/ ataques de asma en la escuela. **Como parte del estudio es necesario conocer si su(s) hijo(s) o hija(s) padecen de asma.** Por esta razón se le solicita cordialmente si puede contestar el cuestionario adjunto a esta carta para poder obtener la información deseada. Este proceso tarda solo unos minutos y la información obtenida será tabulada para procesos estadísticos. El cuestionario intenta obtener información de todos los estudiantes de la escuela de la comunidad Paula Mojica, que son aproximadamente unos 400 estudiantes.

El titulo de la investigación es:
Determinación de riesgo a la exposición de ozono en niños de una escuela elemental en la región geográfica de alta densidad de asma de Caguas, Puerto Rico

Su participación es completamente voluntaria y anónima. Tampoco conlleva ningún riesgo a su persona o familia. Esta se lleva cabo con fines educativos y la confidencialidad a sus respuestas esta garantizada.

El participante se puede retirar en cualquier momento de la investigación sin penalidad alguna.

En caso de surgir cualquier duda sobre el trabajo de investigación se puede contactar a la Oficina de Cumplimiento de Investigaciones del Sistema Universitario Ana G. Méndez al teléfono (787) 751-3120.

_____ _____
Fecha **Firma padre/madre/custodio**

- Esta carta de consentimiento será archivada por el investigador de forma confidencial y segura por cinco (5) años como evidencia del proceso de la investigación y no forma parte del trabajo de Investigación.
- Toda la información será manejada de forma confidencial.
- En caso de duda alguna favor contactar a cualquiera de las personas a continuación:

Ángel F. Villalba Galán, REM
Investigador Principal
(787) 306-5125:743-7979 Ext.4279
manta8@prtc.net

Teresa Lipsett Ruiz, PhD.
Directora Investigación de Tesis
(787) 743-7979. Ext.4267
ut_tlipsett@suagm.edu

- Se releva al departamento de Educación de toda responsabilidad por cualquier reclamación que pueda surgir como consecuencia de las actividades del estudio y de la información que se solicite y provea a través de este.
- El Departamento de Educación no se hace responsable de cualquier daño o reclamación producto del proceso de realización o del resultado de la investigación y la misma es una independiente no auspiciada por el departamento. El Departamento de Educación no necesariamente se solidariza con los resultados de la investigación

APPENDIX 14

Parental consent form. PRDOE & school copy. English version

METROPOLITAN UNIVERSITY
SCHOOL OF ENVIRONMENTAL AFFAIRS

INFORMED CONSENT

FOR MASTER'S DEGREE THESIS IN ENVIRONMENTAL RISK ASSESSMENT & MANAGEMENT

February 15, 2007 Expiration date: May 20, 2007

Esteem parent/ legal custodian:

Greetings! My name is Angel F. Villalba Galan; I am a master's degree student at the School of Environmental Affairs at Metropolitan University in Puerto Rico. By this means I wish to ask for your help in carrying out a scientific study that may be able to benefit your child (ren) by improving the indoor air quality
At Escuela de la Comunidad Paula Mojica in order to diminish asthma episodes among the school children. As part of this study it is necessary to know if your child (dren) suffer(s) from asthma. It is for this reason that I sincerely asks for your time in filling out a questionnaire that is attached to this letter in order to obtain the desired information. This task will only take a couple of minutes and the obtained information wis going to be tabulated for statistical purposes. The questionnaire intends to obtain the same information on all the students at Paula Mojica Elementary School which rounds up to around 400 students.

The title of the investigation is:
Risk assessment to ozone exposure on elementary school children, in the geographical asthma prone region of Caguas, Puerto Rico.

Your participation is completely voluntary and anonymous. It doesn't involve any risk towards your person or your family. It is being carried out for educational purposes and the confidentiality of your answers is guaranteed.
The participant is allowed to stop or to refrain from participating at any time without any penalties.

In case there is/ are any particular doubt(s) about this research you may contact the Office of Research Compliance at Sistema Universitario Ana G. Mendez at (787) 751-3120. This is a direct phone line.

_____
_____

Date Signature
Parent/ guardian

- This Informed Consent letter will be stored in a safe location by the researcher for a period of five (5) years as evidence of the research process. It does not constitute part of the research.
- All of the information / data obtained will be managed confidentially.
- In case of any questions please feel free to contact the following persons:

Angel F. Villalba Galan, REM
Principal Investigator
(787) 306-5125: (787)743-7979 Ext. 4279
Manta8@prtc.net

Teresa Lipsett Ruiz, PhD.
Thesis Director
(787) 743-7979. Ext. 4267
ut_lipsett@suagm.edu