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Introduction

❖ Environmental Science:

Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences (including ecology, biology, physics, chemistry, plant science, zoology, mineralogy, oceanography, limnology, soil science, geology and physical geography, and atmospheric science) to the study of the environment, and the solution of environmental problems. Environmental science emerged from the fields of natural history and medicine during the Enlightenment. Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems.

Environmental studies incorporates more of the social sciences for understanding human relationships, perceptions and policies towards the environment. Environmental engineering focuses on design and technology for improving environmental quality in every aspect.

Environmental scientists study subjects like the understanding of earth processes, evaluating alternative energy systems, pollution control and mitigation, natural resource management, and the effects of global warming and climate change. Environmental issues almost always include an interaction of physical, chemical, and biological processes. Environmental scientists bring a systems approach to the analysis of environmental problems. Key elements of an effective environmental scientist include the ability to relate space, and time relationships as well as quantitative analysis.

Environmental science came alive as a substantive, active field of scientific investigation in the 1960s and 1970s driven by (a) the need for a multi-disciplinary approach to analyze complex environmental problems, (b) the arrival of substantive environmental laws requiring specific environmental protocols of investigation and (c) the growing public awareness of a need for action in addressing environmental problems. Events that spurred this development included the publication

of Rachel Carson's landmark environmental book *Silent Spring*[3] along with major environmental issues becoming very public, such as the 1969 Santa Barbara oil spill, and the Cuyahoga River of Cleveland, Ohio, "catching fire" (also in 1969), and helped increase the visibility of environmental issues and create this new field of study.

Environmental science is the study of patterns and processes in the natural world and their modification by human activity. To understand current environmental problems, we need to consider physical, biological and chemical processes that are often the basis of those problems. This course will give you the skills necessary to address the environmental issues we are facing today by examining scientific principles and the application of those principles to natural systems. This course will survey some of the many environmental science topics at an introductory level, ultimately considering the sustainability of human activities on the planet.

Environmental impacts on Earth come from the number of people and the amount and types of resources that they use. By applying scientific principles and considering real-world examples, we will examine:

- The field of environmental science and how to think like an environmental scientist
- The human population and the ways in which changes in the population affect the environment
- Agriculture, soils and the environmental implications of eating meat, vegetables, local, organic, sustainable, industrial and other types of food
- Non-renewable fossil fuels with a focus on coal, petroleum and natural gas and the benefits and consequences of using each
- Renewable fuels such as wind and solar and identify that even renewable “green” energy sources have impacts as well as benefits
- Biodiversity and global change, which are the integrating units of environmental science

❖ Pollution:

Pollution is the introduction of harmful materials into the environment. These harmful materials are called pollutants. Pollutants can be natural, such as volcanic ash. They can also be created by human activity, such as trash or runoff produced by factories. Pollutants damage the quality of air, water, and land.

Many things that are useful to people produce pollution. Cars spew pollutants from their exhaust pipes. Burning coal to create electricity pollutes the air. Industries and homes generate garbage and sewage that can pollute the land and water. Pesticides—chemical poisons used to kill weeds and insects—seep into waterways and harm wildlife.

All living things—from one-celled microbes to blue whales—depend on Earth's supply of air and water. When these resources are polluted, all forms of life are threatened.

Pollution is a global problem. Although urban areas are usually more polluted than the countryside, pollution can spread to remote places where no people live. For example, pesticides and other chemicals have been found in the Antarctic ice sheet. In the middle of the northern Pacific Ocean, a huge collection of microscopic plastic particles forms what is known as the Great Pacific Garbage Patch.

Air and water currents carry pollution. Ocean currents and migrating fish carry marine pollutants far and wide. Winds can pick up radioactive material accidentally released from a nuclear reactor and scatter it around the world. Smoke from a factory in one country drifts into another country.

In the past, visitors to Big Bend National Park in the U.S. state of Texas could see 290 kilometers (180 miles) across the vast landscape. Now, coal-burning power

plants in Texas and the neighboring state of Chihuahua, Mexico have spewed so much pollution into the air that visitors to Big Bend can sometimes see only 50 kilometers (30 miles).

The three major types of pollution are air pollution, water pollution, and land pollution.

Air Pollution

Sometimes, air pollution is visible. A person can see dark smoke pour from the exhaust pipes of large trucks or factories, for example. More often, however, air pollution is invisible.

Polluted air can be dangerous, even if the pollutants are invisible. It can make people's eyes burn and make them have difficulty breathing. It can also increase the risk of lung cancer.

Sometimes, air pollution kills quickly. In 1984, an accident at a pesticide plant in Bhopal, India, released a deadly gas into the air. At least 8,000 people died within days. Hundreds of thousands more were permanently injured.

Natural disasters can also cause air pollution to increase quickly.
When volcanoes erupt, they eject volcanic ash and gases into the atmosphere. Volcanic ash can discolor the sky for months. After the eruption of the Indonesian volcano of Krakatoa in 1883, ash darkened the sky around the world. The dimmer sky caused fewer crops to be harvested as far away as Europe and North America. For years, meteorologists tracked what was known as the "equatorial smoke stream." In fact, this smoke stream was a jet stream, a wind high in Earth's atmosphere that Krakatoa's air pollution made visible.

Volcanic gases, such as sulfur dioxide, can kill nearby residents and make

the soil infertile for years. Mount Vesuvius, a volcano in Italy, famously erupted in 79, killing hundreds of residents of the nearby towns of Pompeii and Herculaneum. Most victims of Vesuvius were not killed by lava or landslides caused by the eruption. They were choked, or asphyxiated, by deadly volcanic gases.

In 1986, a toxic cloud developed over Lake Nyos, Cameroon. Lake Nyos sits in the crater of a volcano. Though the volcano did not erupt, it did eject volcanic gases into the lake. The heated gases passed through the water of the lake and collected as a cloud that descended the slopes of the volcano and into nearby valleys. As the toxic cloud moved across the landscape, it killed birds and other organisms in their natural habitat. This air pollution also killed thousands of cattle and as many as 1,700 people.

Most air pollution is not natural, however. It comes from burning fossil fuels—coal, oil, and natural gas. When gasoline is burned to power cars and trucks, it produces carbon monoxide, a colorless, odorless gas. The gas is harmful in high concentrations, or amounts. City traffic produces highly concentrated carbon monoxide.

Cars and factories produce other common pollutants, including nitrogen oxide, sulfur dioxide, and hydrocarbons. These chemicals react with sunlight to produce smog, a thick fog or haze of air pollution. The smog is so thick in Linfen, China, that people can seldom see the sun. Smog can be brown or grayish blue, depending on which pollutants are in it.

Smog makes breathing difficult, especially for children and older adults. Some cities that suffer from extreme smog issue air pollution warnings.
The government of Hong Kong, for example, will warn people not to go outside or engage in strenuous physical activity (such as running or swimming) when smog is very thick.

When air pollutants such as nitrogen oxide and sulfur dioxide mix with moisture, they change into acids. They then fall back to earth as acid rain. Wind often carries acid rain far from the pollution source. Pollutants produced by factories and power plants in Spain can fall as acid rain in Norway.

Acid rain can kill all the trees in a forest. It can also devastate lakes, streams, and other waterways. When lakes become acidic, fish can't survive. In Sweden, acid rain created thousands of "dead lakes," where fish no longer live.

Acid rain also wears away marble and other kinds of stone. It has erased the words on gravestones and damaged many historic buildings and monuments. The Taj Mahal, in Agra, India, was once gleaming white. Years of exposure to acid rain has left it pale.

Governments have tried to prevent acid rain by limiting the amount of pollutants released into the air. In Europe and North America, they have had some success, but acid rain remains a major problem in the developing world, especially Asia.

Greenhouse gases are another source of air pollution. Greenhouse gases such as carbon dioxide and methane occur naturally in the atmosphere. In fact, they are necessary for life on Earth. They absorb sunlight reflected from Earth, preventing it from escaping into space. By trapping heat in the atmosphere, they keep Earth warm enough for people to live. This is called the greenhouse effect.

But human activities such as burning fossil fuels and destroying forests have increased the amount of greenhouse gases in the atmosphere. This has increased the greenhouse effect, and average temperatures across the globe are rising. The decade that began in the year 2000 was the warmest on record. This increase in worldwide average temperatures, caused in part by human activity, is called global warming.

Global warming is causing ice sheets and glaciers to melt. The melting ice is causing sea levels to rise at a rate of 2 millimeters (0.09 inches) per year. The rising seas will eventually flood low-lying coastal regions. Entire nations, such as the islands of Maldives, are threatened by this climate change.

Global warming also contributes to the phenomenon of ocean acidification. Ocean acidification is the process of ocean waters absorbing more carbon dioxide from the atmosphere. Fewer organisms can survive in warmer, less salty waters. The ocean food web is threatened as plants and animals such as coral fail to adapt to more acidic oceans.

Scientists have predicted that global warming will cause an increase in severe storms. It will also cause more droughts in some regions and more flooding in others.

The change in average temperatures is already shrinking some habitats, the regions where plants and animals naturally live. Polar bears hunt seals from sea ice in the Arctic. The melting ice is forcing polar bears to travel farther to find food, and their numbers are shrinking.

People and governments can respond quickly and effectively to reduce air pollution. Chemicals called chlorofluorocarbons (CFCs) are a dangerous form of air pollution that governments worked to reduce in the 1980s and 1990s. CFCs are found in gases that cool refrigerators, in foam products, and in aerosol cans.

CFCs damage the ozone layer, a region in Earth's upper atmosphere. The ozone layer protects Earth by absorbing much of the sun's harmful ultraviolet radiation. When people are exposed to more ultraviolet radiation, they are more likely to develop skin cancer, eye diseases, and other illnesses.

In the 1980s, scientists noticed that the ozone layer over Antarctica was thinning. This is often called the "ozone hole." No one lives permanently in Antarctica. But

Australia, the home of more than 22 million people, lies at the edge of the hole. In the 1990s, the Australian government began an effort to warn people of the dangers of too much sun. Many countries, including the United States, now severely limit the production of CFCs.

Water Pollution

Some polluted water looks muddy, smells bad, and has garbage floating in it. Some polluted water looks clean, but is filled with harmful chemicals you can't see or smell.

Polluted water is unsafe for drinking and swimming. Some people who drink polluted water are exposed to hazardous chemicals that may make them sick years later. Others consume bacteria and other tiny aquatic organisms that cause disease. The United Nations estimates that 4,000 children die every day from drinking dirty water.

Sometimes, polluted water harms people indirectly. They get sick because the fish that live in polluted water are unsafe to eat. They have too many pollutants in their flesh.

There are some natural sources of water pollution. Oil and natural gas, for example, can leak into oceans and lakes from natural underground sources. These sites are called petroleum seeps. The world's largest petroleum seep is the Coal Oil Point Seep, off the coast of the U.S. state of California. The Coal Oil Point Seep releases so much oil that tar balls wash up on nearby beaches. Tar balls are small, sticky pieces of pollution that eventually decompose in the ocean.

Human activity also contributes to water pollution. Chemicals and oils from factories are sometimes dumped or seep into waterways. These chemicals are called runoff. Chemicals in runoff can create a toxic environment for aquatic life. Runoff can also help create a fertile environment for cyanobacteria, also called blue-green algae. Cyanobacteria reproduce rapidly, creating a harmful algal bloom (HAB). Harmful

algal blooms prevent organisms such as plants and fish from living in the ocean. They are associated with “dead zones” in the world’s lakes and rivers, places where little life exists below surface water.

Mining and drilling can also contribute to water pollution. Acid mine drainage (AMD) is a major contributor to pollution of rivers and streams near coal mines. Acid helps miners remove coal from the surrounding rocks. The acid is washed into streams and rivers, where it reacts with rocks and sand. It releases chemical sulfur from the rocks and sand, creating a river rich in sulfuric acid. Sulfuric acid is toxic to plants, fish, and other aquatic organisms. Sulfuric acid is also toxic to people, making rivers polluted by AMD dangerous sources of water for drinking and hygiene.

Oil spills are another source of water pollution. In April 2010, the Deepwater Horizon oil rig exploded in the Gulf of Mexico, causing oil to gush from the ocean floor. In the following months, hundreds of millions of gallons of oil spewed into the gulf waters. The spill produced large plumes of oil under the sea and an oil slick on the surface as large as 24,000 square kilometers (9,100 square miles). The oil slick coated wetlands in the U.S. states of Louisiana and Mississippi, killing marsh plants and aquatic organisms such as crabs and fish. Birds, such as pelicans, became coated in oil and were unable to fly or access food. More than 2 million animals died as a result of the Deepwater Horizon oil spill.

Buried chemical waste can also pollute water supplies. For many years, people disposed of chemical wastes carelessly, not realizing its dangers. In the 1970s, people living in the Love Canal area in Niagara Falls, New York, suffered from extremely high rates of cancer and birth defects. It was discovered that a chemical waste dump had poisoned the area’s water. In 1978, 800 families living in Love Canal had to abandon their homes.

If not disposed of properly, radioactive waste from nuclear power plants can escape into the environment. Radioactive waste can harm living things and pollute the water.

Sewage that has not been properly treated is a common source of water pollution. Many cities around the world have poor sewage systems and sewage treatment plants. Delhi, the capital of India, is home to more than 21 million people. More than half the sewage and other waste produced in the city are dumped into the Yamuna River. This pollution makes the river dangerous to use as a source of water for drinking or hygiene. It also reduces the river's fishery, resulting in less food for the local community.

A major source of water pollution is fertilizer used in agriculture. Fertilizer is material added to soil to make plants grow larger and faster. Fertilizers usually contain large amounts of the elements nitrogen and phosphorus, which help plants grow. Rainwater washes fertilizer into streams and lakes. There, the nitrogen and phosphorus cause cyanobacteria to form harmful algal blooms.

Rain washes other pollutants into streams and lakes. It picks up animal waste from cattle ranches. Cars drip oil onto the street, and rain carries it into storm drains, which lead to waterways such as rivers and seas. Rain sometimes washes chemical pesticides off of plants and into streams. Pesticides can also seep into groundwater, the water beneath the surface of the Earth.

Heat can pollute water. Power plants, for example, produce a huge amount of heat. Power plants are often located on rivers so they can use the water as a coolant. Cool water circulates through the plant, absorbing heat. The heated water is then returned to the river. Aquatic creatures are sensitive to changes in temperature. Some fish, for example, can only live in cold water. Warmer river temperatures prevent fish eggs from hatching. Warmer river water also contributes to harmful algal blooms.

Another type of water pollution is simple garbage. The Citarum River in Indonesia, for example, has so much garbage floating in it that you cannot see the water. Floating trash makes the river difficult to fish in. Aquatic animals such as fish and turtles

mistake trash, such as plastic bags, for food. Plastic bags and twine can kill many ocean creatures. Chemical pollutants in trash can also pollute the water, making it toxic for fish and people who use the river as a source of drinking water. The fish that are caught in a polluted river often have high levels of chemical toxins in their flesh. People absorb these toxins as they eat the fish.

Garbage also fouls the ocean. Many plastic bottles and other pieces of trash are thrown overboard from boats. The wind blows trash out to sea. Ocean currents carry plastics and other floating trash to certain places on the globe, where it cannot escape. The largest of these areas, called the Great Pacific Garbage Patch, is in a remote part of the Pacific Ocean. According to some estimates, this garbage patch is the size of Texas. The trash is a threat to fish and seabirds, which mistake the plastic for food. Many of the plastics are covered with chemical pollutants.

Land Pollution

Many of the same pollutants that foul the water also harm the land. Mining sometimes leaves the soil contaminated with dangerous chemicals.

Pesticides and fertilizers from agricultural fields are blown by the wind. They can harm plants, animals, and sometimes people. Some fruits and vegetables absorb the pesticides that help them grow. When people consume the fruits and vegetables, the pesticides enter their bodies. Some pesticides can cause cancer and other diseases.

A pesticide called DDT (dichlorodiphenyltrichloroethane) was once commonly used to kill insects, especially mosquitoes. In many parts of the world, mosquitoes carry a disease called malaria, which kills a million people every year. Swiss chemist Paul Hermann Muller was awarded the Nobel Prize for his understanding of how DDT can control insects and other pests. DDT is responsible for reducing malaria in places such as Taiwan and Sri Lanka.

In 1962, American biologist Rachel Carson wrote a book called *Silent Spring*, which discussed the dangers of DDT. She argued that it could contribute to cancer in humans. She also explained how it was destroying bird eggs, which caused the number of bald eagles, brown pelicans, and ospreys to drop. In 1972, the United States banned the use of DDT. Many other countries also banned it. But DDT didn't disappear entirely. Today, many governments support the use of DDT because it remains the most effective way to combat malaria.

Trash is another form of land pollution. Around the world, paper, cans, glass jars, plastic products, and junked cars and appliances mar the landscape. Litter makes it difficult for plants and other producers in the food web to create nutrients. Animals can die if they mistakenly eat plastic.

Garbage often contains dangerous pollutants such as oils, chemicals, and ink. These pollutants can leech into the soil and harm plants, animals, and people.

Inefficient garbage collection systems contribute to land pollution. Often, the garbage is picked up and brought to a dump, or landfill. Garbage is buried in landfills. Sometimes, communities produce so much garbage that their landfills are filling up. They are running out of places to dump their trash.

A massive landfill near Quezon City, Philippines, was the site of a land pollution tragedy in 2000. Hundreds of people lived on the slopes of the Quezon City landfill. These people made their living from recycling and selling items found in the landfill. However, the landfill was not secure. Heavy rains caused a trash landslide, killing 218 people.

Sometimes, landfills are not completely sealed off from the land around them. Pollutants from the landfill leak into the earth in which they are buried. Plants that grow in the earth may be contaminated, and the herbivores that eat the plants also

become contaminated. So do the predators that consume the herbivores. This process, where a chemical builds up in each level of the food web, is called bioaccumulation.

Pollutants leaked from landfills also leak into local groundwater supplies. There, the aquatic food web (from microscopic algae to fish to predators such as sharks or eagles) can suffer from bioaccumulation of toxic chemicals.

Some communities do not have adequate garbage collection systems, and trash lines the side of roads. In other places, garbage washes up on beaches. Kamilo Beach, in the U.S. state of Hawaii, is littered with plastic bags and bottles carried in by the tide. The trash is dangerous to ocean life and reduces economic activity in the area. Tourism is Hawaii's largest industry. Polluted beaches discourage tourists from investing in the area's hotels, restaurants, and recreational activities.

Some cities incinerate, or burn, their garbage. Incinerating trash gets rid of it, but it can release dangerous heavy metals and chemicals into the air. So while trash incinerators can help with the problem of land pollution, they sometimes add to the problem of air pollution.

Reducing Pollution

Around the world, people and governments are making efforts to combat pollution. Recycling, for instance, is becoming more common. In recycling, trash is processed so its useful materials can be used again. Glass, aluminum cans, and many types of plastic can be melted and reused. Paper can be broken down and turned into new paper.

Recycling reduces the amount of garbage that ends up in landfills, incinerators, and waterways. Austria and Switzerland have the highest recycling rates. These nations recycle between 50 and 60 percent of their garbage. The United States recycles about 30 percent of its garbage.

Governments can combat pollution by passing laws that limit the amount and types of chemicals factories and agribusinesses are allowed to use. The smoke from coal-burning power plants can be filtered. People and businesses that illegally dump pollutants into the land, water, and air can be fined for millions of dollars. Some government programs, such as the Superfund program in the United States, can force polluters to clean up the sites they polluted.

International agreements can also reduce pollution. The Kyoto Protocol, a United Nations agreement to limit the emission of greenhouse gases, has been signed by 191 countries. The United States, the world's second-largest producer of greenhouse gases, did not sign the agreement. Other countries, such as China, the world's largest producer of greenhouse gases, have not met their goals.

Still, many gains have been made. In 1969, the Cuyahoga River, in the U.S. state of Ohio, was so clogged with oil and trash that it caught on fire. The fire helped spur the Clean Water Act of 1972. This law limited what pollutants could be released into water and set standards for how clean water should be. Today, the Cuyahoga River is much cleaner. Fish have returned to regions of the river where they once could not survive.

But even as some rivers are becoming cleaner, others are becoming more polluted. As countries around the world become wealthier, some forms of pollution increase. Countries with growing economies usually need more power plants, which produce more pollutants.

Reducing pollution requires environmental, political, and economic leadership. Developed nations must work to reduce and recycle their materials, while developing nations must work to strengthen their economies without destroying the environment. Developed and developing countries must work together toward the common goal of protecting the environment for future use.

Light Pollution

Light pollution is the excess amount of light in the night sky. Light pollution, also called photopollution, is almost always found in urban areas. Light pollution can disrupt ecosystems by confusing the distinction between night and day. Nocturnal

animals, those that are active at night, may venture out during the day, while diurnal animals, which are active during daylight hours, may remain active well into the night. Feeding and sleep patterns may be confused. Light pollution also indicates an excess use of energy.

The dark-sky movement is a campaign by people to reduce light pollution. This would reduce energy use, allow ecosystems to function more normally, and allow scientists and stargazers to observe the atmosphere.

Noise Pollution

Noise pollution is the constant presence of loud, disruptive noises in an area. Usually, noise pollution is caused by construction or nearby transportation facilities, such as airports.

Noise pollution is unpleasant, and can be dangerous. Some songbirds, such as robins, are unable to communicate or find food in the presence of heavy noise pollution. The sound waves produced by some noise pollutants can disrupt the sonar used by marine animals to communicate or locate food.

Indoor Air Pollution

The air inside your house can be polluted. Air and carpet cleaners, insect sprays, and cigarettes are all sources of indoor air pollution.

Sources and Causes of Pollution

Air pollution comes from both natural and human-made (anthropogenic) sources. However, globally human-made pollutants from combustion, construction, mining, agriculture and warfare are increasingly significant in the air pollution equation.

Motor vehicle emissions are one of the leading causes of air pollution. China, United States, Russia, India Mexico, and Japan are the world leaders in air pollution emissions. Principal stationary pollution sources include chemical plants, coal-fired power plants, oil refineries, petrochemical plants, nuclear waste disposal activity, incinerators, large livestock farms (dairy cows, pigs, poultry, etc.), PVC factories, metals production factories, plastics factories, and other heavy industry. Agricultural air pollution comes from contemporary practices which include clear felling and burning of natural vegetation as well as spraying of pesticides and herbicides

About 400 million metric tons of hazardous wastes are generated each year. The United States alone produces about 250 million metric tons. Americans constitute less than 5% of the world's population, but produce roughly 25% of the world's CO 2, and generate approximately 30% of world's waste. In 2007, China overtook the United States as the world's biggest producer of CO 2, while still far behind based on per capita pollution (ranked 78th among the world's nations).

Some of the more common soil contaminants are chlorinated hydrocarbons (CFH), heavy metals (such as chromium, cadmium – found in rechargeable batteries, and lead – found in lead paint, aviation fuel and still in some countries, gasoline), MTBE, zinc, arsenic and benzene. In 2001 a series of press reports culminating in a book called *Fateful Harvest* unveiled a widespread practice of recycling industrial byproducts into fertilizer, resulting in the contamination of the soil with various metals. Ordinary municipal landfills are the source of many chemical substances entering the soil environment (and often groundwater), emanating from the wide variety of refuse accepted, especially substances illegally

discarded there, or from pre-1970 landfills that may have been subject to little control in the U.S. or EU. There have also been some unusual releases of polychlorinated dibenzodioxins, commonly called *dioxins* for simplicity, such as TCDD.

Pollution can also be the consequence of a natural disaster. For example, hurricanes often involve water contamination from sewage, and petrochemical spills from ruptured boats or automobiles. Larger scale and environmental damage is not uncommon when coastal oil rigs or refineries are involved. Some sources of pollution, such as nuclear power plants or oil tankers, can produce widespread and potentially hazardous releases when accidents occur.

In the case of noise pollution the dominant source class is the motor vehicle, producing about ninety percent of all unwanted noise worldwide.

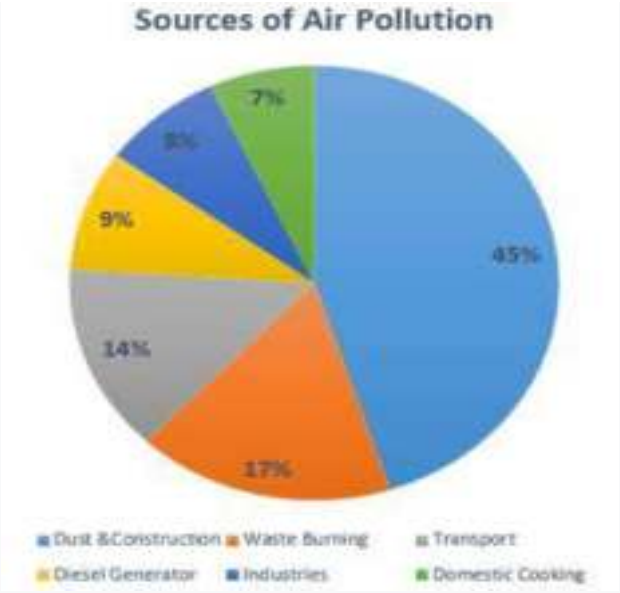
Introduction on Air Pollution

Air pollution is the presence of substances in the atmosphere that are harmful to the health of humans and other living beings, or cause damage to the climate or to materials. There are many different types of air pollutants, such as gases (including ammonia, carbon monoxide, sulfur dioxide, nitrous oxides, methane, carbon dioxide and chlorofluorocarbons), particulates (both organic and inorganic), and biological molecules. Air pollution may cause diseases, allergies, and even death to humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural environment (for example, climate change, ozone depletion or habitat degradation) or built environment (for example, acid rain). Both human activity and natural processes can generate air pollution.

Air pollution is a significant risk factor for a number of pollution-related diseases, including respiratory infections, heart disease, COPD, stroke and lung cancer. Growing evidence suggests that air pollution exposure may be associated with reduced IQ scores, impaired cognition, increased risk for psychiatric disorders such as depression and detrimental perinatal health. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, and the individual's health status and genetics. Outdoor air pollution alone causes 2.1 to 4.21 million deaths annually, making it one of the top contributors to human death. Overall, air pollution causes the deaths of around 7 million people worldwide each year, and is the world's largest single environmental health risk. Indoor air pollution and poor urban air quality are listed as two of the world's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. The scope of the air pollution crisis is enormous: 90% of the world's population breathes dirty air to some degree. Although the health consequences are extensive, the way the problem is handled is often haphazard.

Productivity losses and degraded quality of life caused by air pollution are estimated to cost the world economy $5 trillion per year but, along with health and mortality

impacts, are an externality to the contemporary economic system and most human activity, albeit sometimes being moderately regulated and monitored. Various pollution control technologies and strategies are available to reduce air pollution. To reduce the impacts of air pollution, both international and national legislation and regulation have been implemented to regulate air pollution. Local laws, where well enforced, have led to strong public health improvements. At the international level, some of these efforts have been successful – for example the Montreal Protocol was successful at reducing release of harmful ozone depleting chemicals or the 1985 Helsinki Protocol which reduced sulfur emissions, while other attempts have so far been less successful in implementation, such as international action on climate change.



Dust & Construction contribute about 59% to the air pollution in India, which is followed by Waste Burning. Dust & Construction activities are mostly in the urban areas while Waste Burning is in the rural areas (agriculture).

Air pollution in India is a serious health issue. Of the 30 most polluted cities in the world, 21 were in India in 2019. As per a study based on 2016 data, at least 140 million people in India breathe air that is 10 times or more over the WHO safe limit and 13 of the world's 20 cities with the highest annual levels of air pollution are in India. 51% of the pollution is caused by industrial pollution, 27 % by vehicles, 17% by crop burning and 5% by other sources. Air pollution contributes to the premature deaths of

2 million Indians every year. Emissions come from vehicles and industry, whereas in rural areas, much of the pollution stems from biomass burning for cooking and keeping warm. In autumn and spring months, large scale crop residue burning in agriculture fields – a cheaper alternative to mechanical tilling – is a major source of smoke, smog and particulate pollution. India has a low per capita emissions of greenhouse gases but the country as a whole is the third largest greenhouse gas producer after China and the United States. A 2013 study on non-smokers has found that Indians have 30% weaker lung function than Europeans.

The Air (Prevention and Control of Pollution) Act was passed in 1981 to regulate air pollution but has failed to reduce pollution because of poor enforcement of the rules.

In 2015, Government of India, together with IIT Kanpur launched the National Air Quality Index. In 2019, India launched 'The National Clean Air Programme' with tentative national target of 20%-30% reduction in PM2.5 and PM10 concentrations by 2024, considering 2017 as the base year for comparison. It will be rolled out in 102 cities that are considered to have air quality worse than the National Ambient Air Quality Standards. There are other initiatives such as a 1,600-kilometre-long and 5-kilometre-wide The Great Green Wall of Aravalli green ecological corridor along Aravalli range from Gujarat to Delhi which will also connect to Shivalik hill range with planting of 1.35 billion (135 crore) new native trees over 10 years to combat the pollution. In December 2019, IIT Bombay, in partnership with the McKelvey School of Engineering of Washington University in St. Louis, launched the Aerosol and Air Quality Research Facility to study air pollution in India. According to a **Lancet study**, nearly 16.7 lakh deaths and an estimated loss of USD 28.8 billion worth of output were India's prices for worsening air pollution in 2019.

The rising trends in population growth and the consequent effects on air quality are evident in the Indian scenario. For example, the megacities of Delhi, Mumbai, and Kolkata combined holds a population exceeding 46 million (Gurjar, Ravindra, and Nagpure 2016). Over the years, there has been a massive-scale expansion in industries, population density, anthropogenic activities, and the increased use of automobiles has degraded the air quality in India (Gurjar and Lelieveld 2005). In the last few decades,

the greenhouse gas (GHG) emissions and other emissions resulting from anthropogenic activities have increased drastically (Gurjar and Nagpure 2016).

As per WHO (2016) estimates, 10 out of the 20 most populated cities in the world are in India. Based on the concentrations of $PM_{2.5}$ emissions, India was ranked the fifth most polluted country by WHO (2019), in which 21 among the top 30 polluted cities were in India. The Indian cities, on average, exceeded the WHO threshold by an alarming 500%.

Sources of Air Pollution

The various sources of air pollution are classified into seven major sectors, which include transportation, industries, agriculture, power, waste treatment, biomass burning, residential, construction, and demolition waste.

Vehicular/Transport Emissions

The transportation sector is the main contributor of air pollutants in almost every city, but this phenomenon is worse in urban cities (Gurjar, Aardenne, Lelieveld, et al. 2004). This could be due to the increased number of vehicles when compared to the existing infrastructural facilities, e.g., roads, fuel stations, and the number of passenger terminals provided for public transport. In India, the amount of motorised transport increased from 0.3 million in 1951 to 159.5 million in 2012 (Gurjar, Ravindra, and Nagpure 2016). A significant share of vehicular emissions comes from urban cities, such as Delhi, Mumbai, Bengaluru, and Kolkata. Carbon monoxide (CO), NOX, and NMVOCs are the major pollutants (>80%) from vehicular emissions (Gurjar, Aardenne, Lelieveld, et al. 2004). Other trace emissions include methane (CH4), carbon dioxide (CO2), oxides of sulphur (SOx), and total suspended particles (TSPs).

In an urban environment, road traffic emissions are one of the prime contributors of air pollution. Road dust is a major contributor to PM emissions in Delhi (37%), Mumbai (30%), and Kolkata (61%). Road transport is the largest source of $PM_{2.5}$ in Bengaluru (41%), Chennai (34%), Surat (42%), and Indore (47%) (Nagpure, Gurjar, Kumar, et al. 2016). In the Indian context, some of the essential factors of high traffic emissions include extreme lack of exhaust measures, the highly heterogeneous nature of vehicles, and poor quality of fuel.

Industrial Processes

Over the last few decades, India has witnessed large-scale industrialisation. This has degraded the air quality in most urban cities. The Central Pollution Control Board (CPCB) has categorised the polluting industries into 17 types, which fall under the small and medium scale (Gurjar, Ravindra, and Nagpure 2016). Out of these categories, seven

have been marked as 'critical' industries that include iron and steel, sugar, paper, cement, fertiliser, copper, and aluminium. The major pollutants comprise SPM, SOX, NOX, and CO2 emissions.

The small-scale industries, which are not regulated like the major industries, use several energy sources apart from the primary source of state-provided electricity. Some of these fuels include the use of biomass, plastic, and crude oil. These energy sources are neglected in the current emission inventory studies. In Delhi, after the intervention of the judiciary in 2000, many industries were relocated from urban areas to adjacent rural areas (Nagpure, Gurjar, Kumar, et al. 2016). In Delhi, a major fraction of the pollution load comes from the brick manufacturing industries, which are situated at the outskirts of the city. Rajkot (42%) and Pune (30%) are the two cities where industries play a prominent role in contributing to the highest amount of $PM_{2.5}$ (Nagpure, Gurjar, Kumar, et al. 2016).

Agriculture

Agricultural activities produce emissions, which have the potential to pollute the environment. Ammonia (NH3) and nitrous oxide (N2O) are the key pollutants released from agricultural activities. The other agricultural emissions include methane emissions from enteric fermentation processes, nitrogen excretions from animal manure, such as CH4, N2O, and NH3, methane emissions from wetlands, and nitrogen emissions from agricultural soils (N2O, NOX, and NH3) due to the addition of fertilisers and other residues to the soil (Gurjar, Aardenne, Lelieveld, et al. 2004). Agricultural processes, such as 'slash and burn' are prime reasons for photochemical smog resulting from the smoke generated during the process. Crop residue burning is another process that results in toxic pollutant emissions. This is how neighbouring cities of Delhi contribute to the agricultural pollution load. This is an example of how external sources contribute to the menace of air pollution in the city (Nagpure, Gurjar, Kumar, et al. 2016).

Power Plants

The contribution of power plants to air emissions in India is both immense and worrisome. The thermal power plants manufacture around 74% of the total power

generated in India (Gurjar, Ravindra, and Nagpure 2016). According to The Energy and Resources Institute (TERI), the emissions of SO2, NOX, and PM increased over 50 times from 1947 to 1997. Thermal power plants are the main sources of SO2 and TSP emissions (Gurjar, Aardenne, Lelieveld, et al. 2004), thereby contributing significantly to the emission inventories. In Delhi, power plants contributed 68% of SO2 emissions and 80% of PM10 concentrations over a period from 1990 to 2000 (Gurjar, Aardenne, Lelieveld, et al. 2004). Thus, there is an urgent need to adopt alternative power sources including green and renewable resources for meeting the energy requirements.

Waste Treatment and Biomass Burning

In India, about 80% of municipal solid waste (MSW) is still discarded into open dumping yards and landfills, which leads to various GHG emissions apart from the issues of foul odour and poor water quality at nearby localities. The lack of proper treatment of MSW and biomass burning has been responsible in causing air pollution in urban cities. In Delhi alone, around 5300 tonne of PM10 and 7550 tonne of $PM_{2.5}$ are generated every year from the burning of garbage and other MSW (Nagpure, Gurjar, Kumar, et al. 2016).

Methane (CH4) is the major pollutant released from landfills and wastewater treatment plants. Ammonia (NH3) is another by-product, which is released from the composting process. The open burning of wastes, including plastic, produces toxic and carcinogenic emissions, which are a grave concern (Gurjar, Aardenne, Lelieveld, et al. 2004).

Domestic Sector

Households are identified as a major contributor of air pollution in India. The emissions from fossil fuel burning, stoves or generators come under this sector, thereby affecting the overall air quality. Domestic energy is powered by fuels, such as cooking gas, kerosene, wood, crop wastes or cow dung cakes (Gurjar, Aardenne, Lelieveld, et al. 2004).

Though liquefied petroleum gas (LPG) is used as an alternative source of cooking fuel in most urban cities, the major share of India's rural population continues to rely on cow dung cakes, biomass, charcoal or wood as the primary fuel for cooking and other energy

purposes and demands. These lead to severe implications on air quality, especially the indoor air quality, which could directly affect human health. According to HEI (2019), about 60% of India's population was exposed to household pollution in 2017.

Construction and Demolition Waste

Another major source of air pollution in India is waste, which is an outcome of construction and demolition activities. Guttikunda and Goel (2013) inferred from their study that around 10,750 tonne of construction waste is generated in Delhi every year. Even after the construction phase, these buildings have the potential to be the major contributors of GHG emissions. Nowadays, the increasing interest in green building technologies and the application of green infrastructure and materials during construction could tackle this issue to a large extent, thereby preserving our biodiversity and maintaining cleaner air quality.

Impacts of Air Pollution

On the Ecosystem

The terrestrial ecosystem is widely affected by ground air pollution. The ill-effects include respiratory and pulmonary disorders in animals and humans (Stevens, Bell, Brimblecombe, et al. 2020). The effects on the marine ecosystem include acidification of lakes, eutrophication, and mercury accumulation in aquatic food (Lovett, Tear, Evers, et al. 2009). These processes may indirectly affect the health of the living beings. Similarly, soil acidification is another phenomenon that is common in forest ecosystems as a result of long-term pollutant accumulation. The deposition of sulphate, nitrate, and ammonium is the main reason for soil acidification. Bignal, Ashmore, Headley, et al. (2007) inferred that traces of heavy metals were found in soil samples in areas adjacent to roadways due to cumulative deposition of pollutants. Soil pollution indirectly affects the ecosystems of plants and animals that are reliant on soil for nutritional intake. Nitrogen deposition in wet and dry forms on vegetation and soil surfaces can occur from vehicular and agricultural activities (Driscoll, Whital, Aber, et al. 2003). The results of these activities on the ecosystem have long-term environmental implications, such as global warming and climate change (Lovett, Tear, Evers, et al. 2009). A recent study by Stevens, Bell, Brimblecombe, et al. (2020) discussed four threats to the global ecosystem from pollution, namely, the effects of primary pollutants, such as SO2 and NO2 in a gaseous state, the consequences of wet and dry depositions from SOX and NOX emissions, effects of eutrophication by nitrogen deposition, and the impact of ground-level ozone concentrations.

On Biodiversity

The ill-effects of air pollutant emissions could impact the biological diversity. Though it is evident that air pollution contributes to ground-level emissions, limited studies have been conducted to address the effects on our biodiversity. Acid rain, which is a result of air pollution, is caused by the oxidation and wet deposition of SO2 and NOX emissions in the atmosphere (Rao, Rajasekhar, and Rao 2016). Therefore, acid rain can have harmful effects on our biodiversity.

Nitrogen deposition on plants is a serious outcome of air pollution (Lovett, Tear, Evers, et al. 2009). Bignal, Ashmore, Headley, et al. (2007) investigated three sites adjacent to roadways in the UK to study the impact of pollution on the health of oak and beech trees. Several damages, such as increased defoliation, discolouration, poorer crown condition, and increased pest attacks were observed during the study. It was inferred that significant effects on plants could be found within 100 m from the roadways due to NO2 emissions.

Ozone is another pollutant which is toxic to both plants and animals. Ozone results in reduced photosynthesis and slower growth in plants. In animals and humans, ozone can affect the lung tissues causing respiratory conditions, such as asthma (Stevens, Bell, Brimblecombe, et al. 2020). The effect of ground-level ozone on the crop yield was studied by Sharma, Ojha, Pozzer, et al. (2019), where the researchers evaluated the pan India losses in crop yield and financial problems incurred during 2014–15 due to the ozone. Poor air quality and exposure to anthropogenic pollution had a negative effect on the health of animals as well (Isaksson 2010).

Moreover, the reproductive performance of animals also gets affected due to increased oxidative stress (Isaksson 2010), thereby impacting the population of any species. This may not prove healthy especially for the endangered species. Considering the rapid urbanisation, more focus should be given to this study area in the future.

On Materials and Buildings

SOX and NOX emissions can harm the flora, fauna, material surfaces, and even damage buildings and structures. The negative effects may be in the form of discolouration, loss of material, structural failing, and soiling. This can reduce the service life of buildings and can severely damage historical monuments and structures. One such example is India's white-marble Taj Mahal, which is turning yellow as a result of being exposed to SOX emissions from industries and acid rain. Another historical monument in India is Hyderabad's Charminar, which is turning black due to it being situated in a highly polluted area (Rao, Rajasekhar, and Rao 2016). The erosion of such heritage zones poses a grave concern.

On Human Health

People residing in areas exposed to poor air quality and high pollution levels are prone to hazardous health risks. Such deleterious implications can lead to both minor respiratory disorders and fatal diseases (Gurjar, Jain, Sharma, et al. 2010). Molina, Molina, Slott, et al. (2004) inferred that the studies conducted worldwide had similar conclusions regarding the impact of pollutants on humans. Emissions such as PM, O3, SOX, and NOX have the potential to damage the cardiovascular and respiratory systems of humans. In recent years, the study of human health risks as an outcome of poor air quality has been of prime focus. Gurjar, Jain, Sharma, et al. (2010) evaluated the health risks people in urban areas were prone to due to air pollution in terms of mortality and morbidity. However, there are several limitations associated with the application of this health risk assessment methodology, which must be addressed in the future studies. The HEI (2019) assessed the impact of $PM_{2.5}$ concentrations in India and concluded that around 1.1 million deaths in 2015 were a result of being exposed to air pollution. Upadhyay, Dey, Chowdhury, et al. (2018) inferred that a total of 92,380 lives would have been saved if control measures were applied in the transport, residential, industries, and energy sectors, which are some of the prominent contributors of air pollution.

Gurjar, Ravindra, and Nagpure (2016) concluded in their study that around 30% of Delhi's population complained of respiratory issues due to air pollution in the selected year. Another study by Nagpure, Gurjar, and Martel (2014) evaluated that the mortality rate due to air pollution had doubled between 1990 and 2010 in the capital city. According to Gurjar, Mohan, and Sidhu (1996), the number of premature deaths in Mumbai due to air pollution was recorded at 2800 in 1995, which later increased exponentially to 10,800 in 2010 (Gurjar, Ravindra, and Nagpure 2016). In Kolkata, the premature deaths were estimated to be around 13,500 in 2010. Similarly, Delhi reported about 18,600 premature deaths per year (Lelieveld, Evans, Fnais, et al. 2015).

Air quality standards

The acceptable threshold level of air pollution in terms of its potential impacts on health and environment is defined as the ambient air quality standards. These standards are adopted and enforced by a regulatory body or authority. Every standard should have a

standalone definition and its threshold values should be justified appropriately (Molina, Molina, Slott, et al. 2004). The air quality standards may vary for different countries due to various factors, such as economic conditions, technological know-how, and indigenous air pollution-related epidemiological studies. These are known as the National Ambient Air Quality Standards (NAAQS) in countries, such as India, China, and the US. However, in Canada and the European countries, the limit values are predefined (WHO 2005). Table 1 gives a representation of the different standards adopted by different countries (WHO 2005).

ACT 047 OF 1987 : AIR (PREVENTION AND CONTROL OF POLLUTION) AMENDMENT ACT, 1987

An Act to amend the Air (*Prevention and Control of Pollution*) *Act*, *1981*

Be it enacted by Parliament in the Thirty-eight year of the Republic of India as follows:-

1. Short title and commencement.-(1) This Act may be called the Air (Prevention and Control of Pollution) Amendment Act, 1987.

(2) It shall come into force on such date[1] as the Central Government may, by notification in the Official Gazette, appoint; and different dates may be appointed for different States and for different provisions of this Act.

1 1-4-1988 vide Notification No. G.S.R. 382(E), dated 28-3-1988 (except cis. (ii) and (iv) of Section 2, Section 3, clause (i) of Section 4 and Section 15).

2. Amendment of Section 2.-In Section 2 of the Air (Prevention and Control of Pollution) Act, 1981 (14 of 1981) (hereinafter referred to as the principal Act),-

(*i*) in clause (*a*), after the words "gaseous substance", the brackets and words "(including noise)" shall be *inserted*;

(*ii*) in clause (*g*), for the words "Central Board for the Prevention and Control of Water Pollution", the words " Central Pollution Control Board" shall be *substituted*

(*iii*) for clause (*m*), the following clause shall be *substituted*, namely:-

‘(*m*) "occupier", in relation to any factory or premises, means the person who has control over the affairs of the factory or the premises, and includes, in relation to any substance, the person in possession of the substance;’;

(*iv*) in clause (*o*), in sub-clause (*i*), for the words "State Board for the Prevention and Control of Water Pollution", the words "State Pollution Control Board" shall be *substituted*.

3. Substitution of new sections for Sections 3 and 4.-For Sections 3 and 4 of the principal Act, the following sections shall be *substituted*, namely:-

"3. *Central Pollution Control Board*.-The Central Pollution Control Board constituted under Section 3 of the Water (Prevention and Control of Pollution) Act, 1974, shall, without prejudice to the exercise and performance of its powers and functions under that Act, exercise the powers and perform the functions of the Central Pollution Control Board for the prevention and control of air pollution under this Act.

4. *State Pollution Control Boards constituted under Section 4 of Act 6 of 1974 to be State Boards under this Act*.-In any State in which the Water (Prevention and Control of Pollution) Act, 1974, is in force and the State Government has constituted for that State a State Pollution Control Board under Section 4 of that Act, such State Board shall be deemed to be the State Board for the Prevention and Control of Air Pollution constituted under Section 5 of this Act, and accordingly that State Pollution Control Board shall, without prejudice to the exercise and performance of its powers and functions under that Act, exercise the powers and perform the functions of the State Board for the prevention and control of air pollution under this Act.".

4. Amendment of Section 5.-In Section 5 of the principal Act,-

(*i*) in sub-section (1), for the words "State Board for the Prevention and Control of Water Pollution", the words "State Pollution Control Board" shall be *substituted*;

(*ii*) in sub-section (2), for clause (*f*), the following clause shall be *substituted*, namely:-

"(*f*) a full-time member secretary having such qualifications, knowledge and experience of scientific, engineering or management aspects of pollution control as may be prescribed, to be appointed by the State Government:".

5. Amendment of Section 7.-In sub-section (6) of Section 7 of the principal Act, the words "but not for more than two terms" shall be *omitted*.

6. Amendment of Section 14.-In Section 14 of the principal Act, for sub-section (2), the following sub-section shall be *substituted*, namely:-

"(2) The member-secretary of a State Board, whether constituted under this Act or not, shall exercise such powers and perform such duties as may be prescribed, or as may, from time to time, be delegated to him by the State Board or its Chairman.".

7. Amendment of Section 16.-In sub-section (2) of Section 16 of the principal Act, after clause (*d*), the following clause shall be *inserted*, namely:-

"(*dd*) perform such of the functions of any State Board as may be specified in an order made under sub-section (2) of Section 18;"

8. Amendment of Section 18.-Section 18 of the principal Act shall be *renumbered* as sub-section (1) thereof, and after sub-section (1) as so *renumbered*, the following sub-sections shall be *inserted*, namely:-

"(2) Where the Central Government is of the opinion that any State Board has defaulted in complying with any directions given by the Central Board under sub-section (1) and as a result of such default a grave emergency has arisen and it is necessary or expedient so to do in the public interest, it may, by order, direct the Central Board to perform any of the functions of the State Board in relation to such area, for such period and for such purposes, as may be specified in the order.

(3) Where the Central Board performs any of the functions of the State Board in pursuance of a direction under sub-section (2), the expenses, if any, incurred by the Central Board with respect to the performance of such functions may, if the State Board is empowered to recover such expenses, be recovered by the Central Board with interest (at such reasonable rate as the Central Government may, by order, fix) from the date when a demand for such expenses is made until it is paid from the person or persons concerned as arrears of land revenue or of public demand.

(4) For the removal of doubts, it is hereby declared that any directions to perform the functions of any State Board given under sub-section (2) in respect of any area would not preclude the State Board from performing such functions in any other area in the State or any of its other functions in that area.".

9. Amendment of Section 21.-In Section 21 of the principal Act,-

(*i*) for sub-section (1), the following sub-section shall be *substituted*, namely:-

"(1) Subject to the provisions of this section, no person shall, without the previous consent of the State Board, establish or operate any industrial plant in an air pollution control area:

Provided that a person operating any industrial plant in any air pollution control area immediately before the commencement of Section 9 of the Air (Prevention and Control of Pollution) Amendment Act, 1987, for which no consent was necessary prior to such commencement, may continue to do so for a period of three months from such commencement or, if he has made an application for such consent within the said period of three months till the disposal of such application.";

(*ii*) in the proviso to sub-section (2), the words "for the purpose of any industry specified in the Schedule" shall be *omitted*;

(*iii*) in sub-section (4),-

(*a*) for the words "either grant or refuse, for reasons to be recorded in the order, the consent applied for", the words "and for reasons to be recorded in the order, grant the consent applied for subject to such conditions and for such period as may be specified in the order, or refuse such consent" shall be *substituted*;

(*b*) the following provisos shall be *inserted* at the end namely:-

"Provided that it shall be open to the State Board to cancel such consent before the expiry if the conditions subject to which such consent has been granted are not fulfilled:

Provided further that before cancelling a consent or refusing a further consent under the first proviso, a reasonable opportunity of being heard shall be given to the person concerned.";

(*iv*) in the first proviso to sub-section (5), the words "for the purpose of any industry specified in the Schedule" shall be *omitted*;

10. Amendment of Section 22.-In Section 22 of the principal Act, the words "carrying on any industry specified in the Schedule or" shall be *omitted*.

11. Insertion of new Section 22-A.-After Section 22 of the principal Act, the following section shall be *inserted*, namely:-

"22-A. *Power of Board to make application to court for restraining persons from causing air pollution*.-(1) Where it is apprehended by Board that emission of any air pollutant, in excess of the standards laid down by the State Board under clause (*g*) of sub-section (1) of Section 17, is likely to occur by reason of any person operating an industrial plant or otherwise in any air pollution control area, the Board may make an application to a court, not inferior to that of a Metropolitan Magistrate or a Judicial Magistrate of the first class for restraining such person from emitting such air pollutant.

(2) On receipt of the application under sub-section (1), the court may make such order as it deems fit.

(3) Where under sub-section (2), the court makes an order restraining any person from discharging or causing or permitting to be discharged the emission of any air pollutant, it may, in that order,-

(*a*) direct such person to desist from taking such action as is likely to cause emission;

(*b*) authorise the Board, if the direction under clause (*a*) is not complied with by the person to whom such direction is issued, to implement the direction in such manner as may be specified by the court.

(4) All expenses incurred by the Board in implementing the directions of the court under clause (*b*) of sub-section (3) shall be recoverable from the person concerned as arrears of land revenue or of public demand.".

12. Amendment of Section 23.-In Section 23 of the principal Act, in sub-section (1), the words "air pollution control" shall be *omitted*.

13. Amendment of Section 24.-In Section 24 of the principal Act, in sub-section (2), the words "carrying on any industry specified in the Schedule and every person" shall be *omitted*.

14. Insertion of new Section 31-A.-In Chapter IV of the principal Act, after Section 31, the following section shall be *inserted*, namely:-

"31-A. *Power to give directions*.-Notwithstanding anything contained in any other law, but subject to the provisions of this Act and to any directions that the Central

Government may give in this behalf, a Board may, in the exercise of its powers and performance of its functions under this Act, issue any directions in writing to any person, officer or authority, and such person, officer or authority shall be bound to comply with such directions.

Explanation.-For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct-

(*a*) the closure, prohibition or regulation of any industry, operation or process; or

(*b*) the stoppage or regulation of supply of electricity, water or any other service.".

15. Amendment of Sections 32, 33 and 49.-In the proviso to Section 32, in sub-section (3) of Section 33 and in Section 49 of the principal Act, for the words "State Board for the Prevention and Control of Water Pollution", wherever they occur, the words " State Pollution Control Board" shall be *substituted*.

16. Insertion of new Section 33-A.-After Section 33 of the Principal Act, the following section shall be *inserted*, namely:-

"33-A. *Borrowing powers of Board*.-A Board may, with the consent of, or in accordance with the terms of any general or special authority given to it by, the Central Government or, as the case may be, the State Government, borrow money from any source by way of loans or issue of bonds, debentures or such other instruments, as it may deem fit, for discharging all or any of its functions under this Act.".

17. Substitutions of new section for Section 35.-For Section 35 of the principal Act, the following section shall be *substituted*, namely:-

"35. *Annual report*.-(1) The Central Board shall, during each financial year, prepare, in such form as may be prescribed, an annual report giving full account of its activities under this Act during the previous financial year and copies thereof shall be forwarded to the Central Government within four months from the last date of the previous financial year and that Government shall cause every such report to be laid before both Houses of Parliament within nine months of the last date of the previous financial year.

(2) Every State Board shall, during each financial year, prepare, in such form as may be prescribed, an annual report giving full account of its activities under this Act during the previous financial year and copies thereof shall be forwarded to the State Government within four months from the last date of the previous financial year and that Government shall cause every report to be laid before the State Legislature within a period of nine months from the last date of the previous financial year.".

18. Substitution of new section for Section 37.-For Section 37 of the principal Act, the following section shall be *substituted*, namely:-

"37. *Failure to comply with the provisions of Section 21 or Section 22 or with the directions issued under Section 31-A*.-(1) Whoever fails to comply with the provisions of Section 21 or Section 22 or directions issued under Section 31-A, shall, in respect of each such failure, be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine, and in case the failure continues, with an additional fine which may extend to five thousand rupees for every day during which such failure continues after the conviction for the first such failure.

(2) If the failure referred to in sub-section (1) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a terms which shall not be less than two years but which may extend to seven years and with fine."

19. Amendment of Section 38.-In Section 38 of the principal Act, for the words "five hundred rupees", the words "ten thousand rupees' shall be *substituted*.

20. Substitution of new section for Section 39.-For Section 39 of the principal Act, the following section shall be *substituted*, namely:-

"39. *Penalty for contravention of certain provisions of the Act*.-Whoever contravenes any of the provisions of this Act or any order or direction issued thereunder, for which no penalty has been elsewhere provided in this Act, shall be punishable with imprisonment for a term which may extend to three months or with fine which may extend to ten thousand rupees or with both, and in the case of continuing contravention,

with an additional fine which may extend to five thousand rupees for every day during which such contravention continues after conviction for the first such contravention.".

21. Substitution of new section for Section 43.-For Section 43 of the principal Act, the following section shall be *substituted*, namely:-

"43. *Cognizance of offences*.-(1) No court shall take cognizance of any offence under this Act except on a complaint made by-

(*a*) a Board or any officer authorised in this behalf by it; or

(*b*) any person who has given notice of not less than sixty days, in the manner prescribed, of the alleged offence and of his intention to make a complaint to the Board or officer authorised as aforesaid.

and no court inferior to that of a Metropolitan Magistrate or a Judicial Magistrate of the first class shall try any offence punishable under this Act.

(2) Where a complaint has been made under clause (*b*) of sub-section (1), the Board shall, on demand by such person, make available the relevant reports in its possession to that person:

Provided that the Board may refuse to make any such report available to such person if the same is, in its opinion, against the public interest.".

22. Omission of Section 50.-Section 50 of the principal Act shall be *omitted*.

23. Amendment of Section 53.-In Section 53 of the principal Act, in sub-section (1), for clause (*f*), the following clause shall be *substituted*, namely:-

"(*f*) the form in which and the time within which the budget of the Central Board may be prepared and forwarded to the Central Government under Section 34;

(*ff*) the form in which the annual report of the Central Board may be prepared under Section 35;".

24. Amendment of Section 54.-In Section 54 of the principal Act,-

(*a*) in sub-section (2),-

(*i*) clause (*a*) shall be *renumbered* as clause (*aa*), and before clause (*aa*) as so *renumbered*, the following clause shall be *inserted*, namely:-

"(*a*) the qualifications, knowledge and experience of scientific, engineering or management aspects of pollution control required for appointment as member-secretary of a State Board constituted under the Act;";

(*ii*) for clause (*w*), the following clause shall be *substituted*, namely:-

"(*w*) the form in which and the time within which the budget of the State Board may be prepared and forwarded to the State Government under Section 34;

(*ww*) the form in which the annual report of the State Board may be prepared under Section 35;";

(*iii*) after clause (*x*), the following clause shall be *inserted* namely:-

"(*xx*) the manner in which notice of intention to make a complaint shall be given under Section 43;";

(*b*) in sub-section (3), for the words brackets and letter "in clause (*a*)" the words, brackets and letters "in clause (*aa*)" shall be *substituted*.

25. Omission of the Schedule.-The Schedule to the principal Act shall be *omitted*.

Current Air Quality Index In India

Air quality index (AQI) and PM2.5 air pollution in India

How polluted is India?

2020 Air quality average

Unhealthy for Sensitive Groups
2020 average US AQI
141

!

PM2.5
x10.4

PM2.5 concentration in India air is currently 10.4 times above the WHO annual air quality guideline value

2020 India cleanest city

Satna , Madhya Pradesh
62

2020 India most polluted city

Ghaziabad , Uttar Pradesh
177

2020 AQI COUNTRY RANKING

How does India rank globally in air pollution?

3 / 106 countries ranked in 2020

Which country had the worst air quality in 2020?

#	COUNTRY	POPULATION	AVG. US AQI
1	 Bangladesh	164’689’383	162
2	 Pakistan	220’892’331	153
3	 India	1’380’004’385	141
4	 Mongolia	3’278’292	128
5	 Afghanistan	38’928’341	128
6	 Oman	5’106’622	123
7	 Qatar	2’881’060	123
8	 Kyrgyzstan	6’524’191	121
9	 Indonesia	273’523’621	114
10	 Bosnia Herzegovina	3’280’815	113

How bad is India's air pollution?

In 2019, as part of a worldwide survey, it was discovered that 21 out of the 30 most polluted cities were in India. And this pushed India's ranking as a country to 5th place, according to figures published by iqair.com. The US AQI number averaged out at 152 and the PM2.5 figure recorded was 58.08µg/m³. This concentration was 5 times higher than that recommended by the World Health Organisation (WHO). This is an overall improvement on the 2018 figure of 72.54µg/m³. This means serious health problems for most of the country.

Over 50 over cent of this pollution comes from industry, followed by 27 per cent from vehicles, 17 per cent from crop burning and 7 per cent by domestic cooking. Over 2 million Indians lose their life to causes attributed to air pollution.

In the urban areas, most of the pollution comes from industry and vehicles, whereas in the rural areas, most comes from the burning of organic material. This material is used as a fuel for the domestic stoves, and also in the heaters needed to keep the houses warm in the colder months. During autumn and winter, huge amounts of stubble are burnt in the fields as a way of preparing the ground for the next crop. This method is much cheaper than the alternative option of ploughing the residue back into the land. This can be particularly bad as garbage is often thrown into the fires by way of disposal.

This combines with other pollutants to rank India as the world's third greatest producer of greenhouse gases, behind China and the USA. The Air (Prevention and Control of Pollution) Act was inaugurated in the early '80s but has failed to make an impact due to the poor enforcement of the rules.

Official attitudes to the poor air quality is changing, especially since schools in Delhi had to close for several days in December 2017 due to the dangerous levels of pollutants present in the air. As more people are aware of the consequences of breathing poor quality air, the pressure is mounting on the authorities to do something about it.

What are the sources of India's polluted air?

Fuel used for domestic stoves is usually made from a wet mixture of pieces of wood, dried leaves, hay and dried animal dung. This is fashioned into discs and dried in the sunshine. When it is burned in the stoves or chullas, it produces smoke and other pollutants five times higher than if coal were burnt. It is thought that in excess of 100 million households use these stoves up to 3 times a day, 7 days a week. Electricity or other clean fuels are not available in many remote areas. Even in cities where electricity is available, it is traditional to use these types of stove and 24 percent of city pollutants are attributed to such habits.

Some Indian auto-rickshaws and taxis run on fuel that has been adulterated by other, cheaper ingredients. This is a common occurrence in all of South Asia. The taxation system in India exacerbates this situation because gasoline carries a much higher rate of tax than diesel. This, in turn, carries a higher level than kerosene because kerosene is intended to be used as a cooking fuel. Other volatile liquids such as lubricants and solvents carry little or no tax and therefore make ideal ingredients to mix with the higher-priced fuels. To a low wage earner, this adulteration can save as much as 30 per cent over the period of one month.

Traffic congestion is a huge problem in India's large cities and towns due to the number of cars trying to use what roads are available. Other factors include a lack of intra-city divided highways and traffic accidents due to the chaotic conditions on India's roads due to the lackadaisical enforcement of the laws. Because of the bottle-necks created by junctions, traffic remains at a standstill with the engines idling. Monitoring stations near some of the large intersections record noticeably higher figures than those recorded elsewhere.

Dust produced from the demolition and subsequent building of new properties contributes to the poor quality of air in the city. During the dry season, dust is blown in

from the desert-dry countryside and deposited in the city when the wind pressure drops as it travels over the buildings.

The air quality in the capital of Delhi always drops to the "severe" category during the winter months. Primarily, this is due to the practice of burning the stubble after the harvest to prepare for the planting of next season's crop. It is reported that this alone is responsible for 32 per cent of Delhi's PM2.5 particulate matter. At 292micrograms per cubic metre, the figure is 5 times higher than the World Health Organisation's recommended safe limit. Weather conditions play an important part in the dispersal of airborne particles through both wind and rain.
Another major contributor to the air pollution was the Badarpur Thermal Power Station. This was built in 1973 and produced a mere 8 per cent of Delhi's electricity yet was accountable for 80-90 per cent of the particulate matter. In November 2017 during "The Great Smog of Delhi" it was temporarily shut down to alleviate the smog but restarted the following February. However, due to the amount of pollution it created, it was shut down permanently in late 2018.

What effects does this poor air quality have on health?

The levels of the pollutant PM 2.5 are often well above the World Health Organisation's recommended level of exposure (often over 5 times higher) and this leads to serious respiratory problem for those exposed to it. This is from both outside and household air pollution. Records show that in 2019 over 1.6 million deaths were attributed to poor air quality. The cause of death ranged from strokes, diabetes, lung cancer and myocardial infarctions. Also in this year, the State of Global Air 2020 noted that air pollution is now the largest risk factor for death amongst all other forms.

Household and outdoor particulate matter pollution was the main cause of death for more than 100,000 infants during the first month of their lives. A large percentage of

these deaths were linked to the use of solid fuel biomass (charcoal, wood and dried dung cakes) used for cooking and heating homes.

In comparison to other countries, Indians are exposed to an average of 83.2 μg/cubic metre of PM2.5 pollutants compared to cleaner countries which record a relatively tiny figure of just 8μg / cubic metre.

Poor air quality has a drastic effect on the human respiratory system because the small PM 2.5 particulates travel deep into the lung tissue as far as the alveoli. From here they can pass through body tissue and can even enter the heart. Reduced lung capacity, sore throats, coughs, fatigue, lung cancer and headaches are all typical symptoms of exposure to polluted air.

A doctor from Delhi's Sir Ganga Ram Hospital remarked that when he first started practising some 30 years ago, most of his patients suffering from lung cancer were male smokers in their 60s. But recently the doctor has reported that his patients now are usually non-smokers, and some 40 per cent are female. He also noticed that the patients are now a lot younger with around 10 per cent being in their 30s and 40s. Even in the lungs of teenage patients, black deposits can be found which would have been unthinkable 30 years ago. COPD or chronic obstructive pulmonary disease is now the second-largest cause of death behind heart disease.

It has been noted that the levels of PM2.5 particles are affected by the population density

Can India's air quality be improved?

At the beginning of 2019 the Indian government inaugurated the National Clean Air Program (NCAP) to address the situation. It is their aim to reduce levels of air pollution by 20-30 per cent by 2024 in over 122 of the worst affected cities. Actions being taken in New Delhi, Ahmedabad and Pune include the implementation of health risk

communications plans, the increase in the number of monitoring stations and better control of industrial emissions.

NCAP routinely monitors the four air pollutants of sulphur dioxide (SO2), oxides of nitrogen (both NO2 and NO), PM10 particulates and suspended particulate matter (SMP). These are to be monitored at 308 stations in 115 towns and cities over 25 states and 4 territories. Meteorological readings are also recorded such as wind speed and direction, relative humidity and temperature. Readings are taken on a regular basis for both particulate matter and for gaseous pollutants. These readings are taken twice a week and will generate 104 observations over a period of 1 year.

Several cities, including Solapur and Ahmedabad have seen a reduction in PM10 particulates over the last few years. This is thought to be due to the measures taken to reduce sulphur from diesel fuel and stronger enforcement by the local authorities.

Sulphur Dioxide levels are decreasing in residential areas of Delhi. Mumbai, Lucknow and Bophal in recent years. This has been attributed to the introduction of cleaner fuels and the increased availability and usage of Liquid Natural Gas (LNG). The latter being encouraged for use as an alternative to biomass in household cooking stoves and in auto-rickshaws.

The government in New Delhi introduced the “odd/even” rule in late 2017. This simply means that cars with a registration plate ending in an even number are excluded from the city centre on certain days of the week. The same rule applies to the odd numbers for different days.

India’s goals over the next few years to reduce air pollution include the introduction of over 1,000 electrically powered buses and the upgrading of engines using fossil fuels to meet the stringent BS6 standards. It is hoped that by 2023 25 per cent of all privately owned vehicles on Indian roads will be Electric Vehicles (EVs), and all power plants will be using renewable energy too. Any vehicle older than 15 years or that fall below the BS6 emission standards will be banned from city roads.

In rural areas, farmers are being encouraged to hire a machine which converts organic waste to fertilizer thus eliminating the need to burn the straw at the end of each harvest.

With the advent of new technology, it will be easier to send information to the public to warn them about certain changes in the air quality.

The reduction of carbon emissions is hoped to reduce CO2 gases by 20 per cent by 2030 and to reach zero by 2075.

One of the initiatives being considered is the creation of a 1,600 kilometre long and 5 metre wide “green” corridor from Gujarat to Delhi with the planting of 1.35 billion native trees over the next ten years in order to naturally clean the air.

Delhi is almost free from the use of kerosene as a fuel and almost 90 per cent of the residents now use LPG (NPG) for cooking. The remaining 10 per cent still rely on the traditional fuels of wood, coal and dried animal dung.

By 2021, it is expected that the centre of Delhi will be solely powered by clean, sustainable energy

Where is the cleanest air in India?

The cleanest city in India is Satna in the state of Madhya Pradash with a 2019 PM2.5 reading of 15.5µg/m³ and a US AQI figure of 58. The next cleanest city was Kumbhori in the state of Maharashtra with a figure of 20.3µg/m³. Compare these figures with the dirtiest air which is found in Ghaziabad in Uttar Pradesh with a reading of 115µg/m³ and a US AQI figure of 179 and the second dirtiest city of Delhi with a recorded figure of 100µg/m³.

In certain areas of India, air quality has been getting better since 2018, albeit very slightly. The number of days when the pollutants were above recommended levels for PM2.5 fell in 2019 by comparison.

The geography of Northern India and its proximity to the Himalayas means that it is very difficult for polluted air to escape. During the winter months when the strength of the wind is greatly reduced, the area can be thought of as a bowl with nowhere for the pollutants to escape.

Literature Review

Many people live in place where the actual air quality is above the World Health Organization's suggested limits for pollutants. Air Pollution is currently the most severe environmental problem and the public health concern in the world, especially in developing countries. Studies have mostly focussed on the casual effect of pollution on health, and numerous economic studies have documented that pollution is severely harmful to human health, in both developed and developing countries.

With rapid industrialization, energy consumption has increased dramatically. As energy raises our quality of life to higher levels, it also puts our health at risk. There is now a growing literature on the impacts of energy accidents and consumption on pollution and health. It finds that pollution is the most relevant channel related to the heaths impacts of energy. Recent research suggests that the health of pregnant women, children, and infants is at greater risk of being adversely affected by pollution (e.g., Currie & Neidell,2005; Janke,2014). Many studies suggest that infants are sensitive to the pollution caused by oil spills and coal smoke. In addition, studies are increasingly suggesting that clean energy policies and environmental regulations can abate the negative health effects of energy-related pollution.

This paper reviews the recent literature that studies the effects of energy on pollution and health. The core of this casual evaluation addresses the endogeneity problem. Using exogenous energy accidents and policy experiments and regulations as exogenous events to test causality, the literature is mainly based on difference-in-differences and regression discontinuity designs.

On the other hand, given the pollution explosion and rapid urbanization, energy consumption and the volume of long-distance energy transnational transportation has increased rapidly, and energy accidents, such as oil spill in the Gulf of Mexico in 2010 and the nuclear leak od Fukushima Daiichi in Japan, are occurring frequently. Therefore, research has documented the impacts of energy accidents on pollution and human health. In response to public concerns over the increasing pollution threat from energy consumption and accidents, governments can put forward various policies and

regulations to mitigate the negative health effect. Therefore, this paper aims to review the recent literature and determine how energy affects pollution and health.

Although environmental pollution can be caused by natural events such as forest fires and active volcanoes, use of the word pollution generally implies that the contaminants have anthropogenic source-that is, a source created by human activities. Pollution has accompanied humankind ever since groups of people first congregated and remained for a long time in any one place. Indeed, ancient human settlements are frequently recognized by their wastes-shell mounds and rubble heaps, for instance. Pollution was not a serious problem as long as there was enough space available for each individual or group. However, with the establishment of permanent settlements by great numbers of people pollution became a problem and it has remained one ever since.

Objective of Study on Air Pollution

The present study is based on the following:

1. To study the take of people on the current polluted state.
2. To study in what ways air pollution is affecting the daily lives of the people.
3. To study what according to the people are the main causes of the polluted environment.
4. To study about what impact can pollution have on our health.
5. To study what would it take to control pollution in our country.

Research Methodology

a. DATA TYPE:

- **Primary Data: -** Data that has been generated by the researcher himself/herself, surveys, interviews, experiments, specially designed for understanding and solving the research problem at hand. Primary data are usually collected from the source—where the data originally originates from and are regarded as the best kind of data in research.
- **Secondary Data: -** Using existing data generated by large government Institutions, healthcare facilities etc. as part of organizational record keeping. The data is then extracted from more varied datafiles. The data may also have been collected for general use with no specific research purpose like in the case of the national census.

b. SIZE:

Individuals – 20

c. ANALYTICAL TOOLS:

- Bar Chart, Pie Diagram
- Diagrams
- Tables

Data Collection & Analysis

- **Sample Questionaire:**

Survey on Air Pollution

This survey is for a study regarding the current status of Air Pollution in our country.

*Required

1. Name *

Your answer

2. Gender *

Male

Female

Other:

3. Age *

Your answer

4. How would you rate the overall air quality in your city now compared to last year? *
   a. Much better

b. A little better
c. About the same
d. A little worse
e. Much worse

5. What do you think are the main causes of air pollution in your city? Please select all applicable. *

- Construction
- Industrial sources
- Increasing use of Air Conditioner
- Motor Vehicles
- Household cooking and heating
- Population Growth
- Power Plants
- Smoke of cigarettes
- Waste Disposal
- Burning Of Waste
- Pollution from other countries
- Other:
-

6. To what extent is the air pollution affecting you? *
   a. Very much affected
   b. Affected a little
   c. Not affected at all
7. In which of the following ways are you affected? Please select all applicable. *

- Breathlessness/Having more difficulty in breathing
- Doing less outdoor activities
- Doing more to look after my skin

- Doing more to stay healthy
- Feeling depressed
- Irritation to eyes/nose/throat
- Skin problems
- Wanting to move to less polluted place
- Asthma incidences
- Poor Visibility
- Worrying about the living environment for children
- Other:
-

8. "Polluting companies should be fined even if it puts some jobs at risk," *

(Please express how much do you agree or disagree on the given statements).

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

9. "Power stations and factories should switch to cleaner processes even if consumer bills and prices have to go up." *

(Please express how much do you agree or disagree on the given statements.)

a. Strongly agree
b. Agree

c. Neutral
d. Disagree
e. Strongly disagree

10."Improving the environment is the responsibility of every citizen." *

(Please express how much do you agree or disagree on the given statements.)

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

11."I am actively involved in cleaning up the environment ." *

(Please express how much do you agree or disagree on the given statements.)

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

12."I do not see pollution as a problem." *

(Please express how much do you agree or disagree on the given statements.)

a. Strongly agree
b. Agree
c. Neutral
d. Disagree

e. Strongly disagree

13. "If I knew how to better contribute to a cleaner environment, I would take action." *

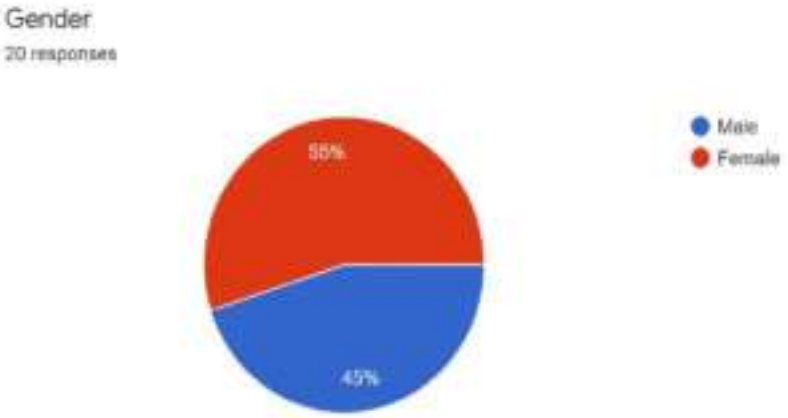
(Please express how much do you agree or disagree on the given statements.)

a. Strongly agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

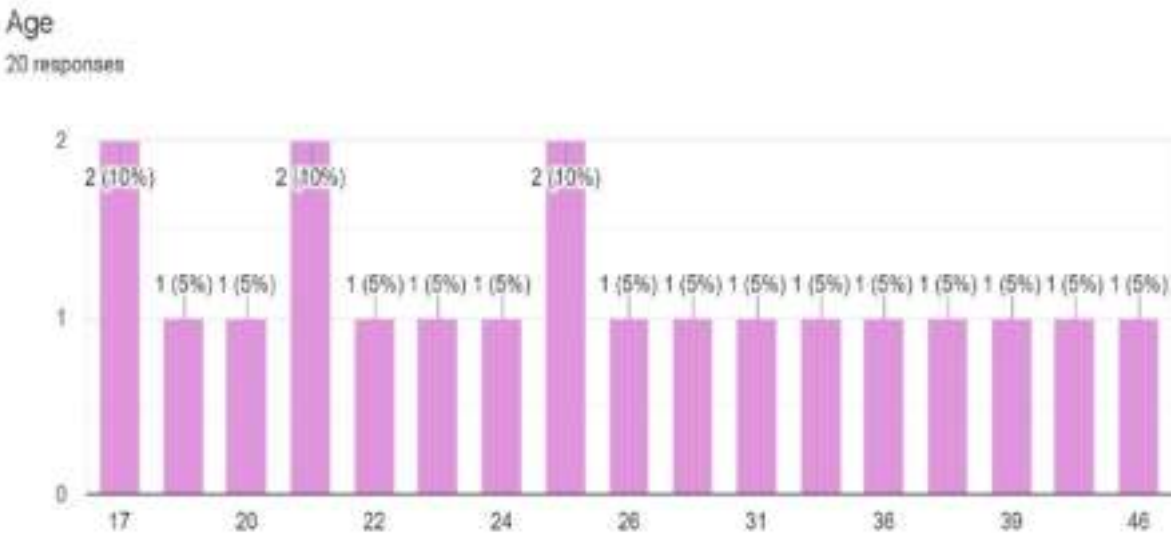
- **Name:**

S. No.	Name
1.	Aastha Chaudhary
2.	Mahima
3.	Shreya Bhatia
4.	Kriti
5.	Kiran
6.	Vihaan Khanna
7.	Rajeev
8.	Gaurav Arora
9.	Himanshu
10.	Ekta
11.	Vaishali Bhatia
12.	Manoj
13.	Kanishka
14.	Vanita
15.	Simon
16.	Vaibhav Bhatia
17.	Yogita Sharma
18.	Sampreet Chandok
19.	Shaurya Pandey
20.	Aarti Khanna

- **Gender:**


Gender
20 responses
55%
45%
Male
Female

- **Age:**


Age
20 responses
2
1
0
2 (10%)
1 (5%)
1 (5%)
2 (10%)
1 (5%)
1 (5%)
1 (5%)
2 (10%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
1 (5%)
17
20
22
24
26
31
38
39
46

QUESTIONS OVERVIEW

1. How would you rate the overall air quality in your city now compared to last year?

Primary Data: Table-1.1

How would you rate the overall air quality in your city now compared to last year?	
Responses	**Data**
Much Better	2
A little better	2
About the same	5
A little worse	6
Much worse	5
Total	20

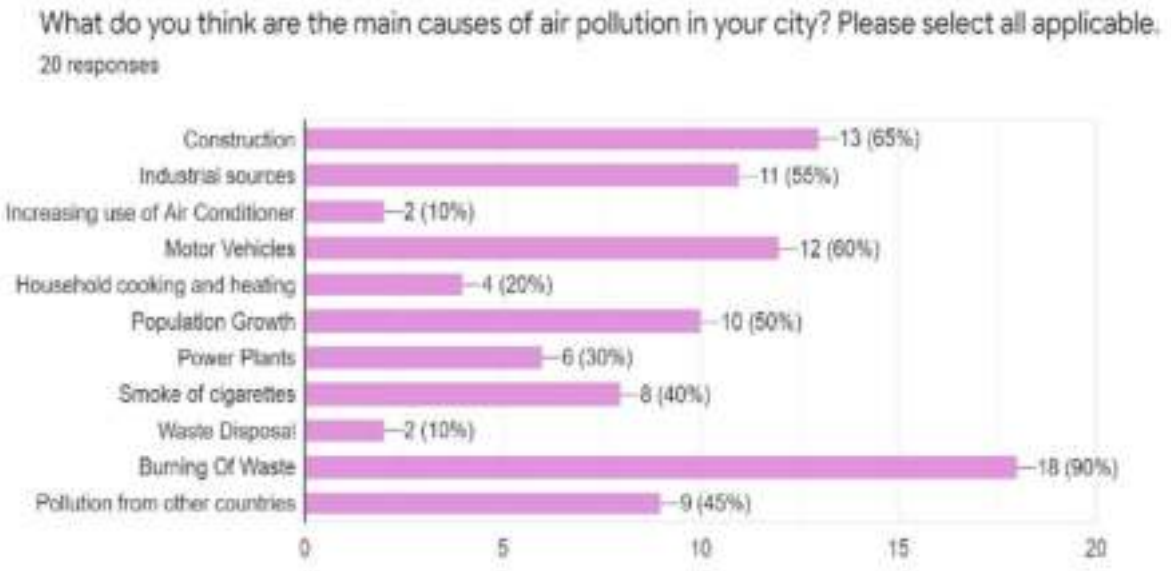
❖ Interpretation:

The survey of 20 different individuals was taken about the overall air quality of their city as compared to the last year. According to the analysis it indicates that **[Much better (2), A little better (2), About the same (5), A little worse (6), Much worse (5)]** more than **50%** of the people believe that the air quality has worsened much more than the last year.

2. What do you think are the main causes of air pollution in your city? Please select all applicable.

Primary Data Table-1.2

What do you think are the main causes of air pollution in your city? Please select all applicable.	
Reponses	**Data**
Construction	13
Industrial sources	11
Increasing use of Air Conditioner	2
Motor Vehicles	12
Household cooking and heating	4
Population Growth	10
Power Plants	6
Smoke of cigarettes	8
Waste Disposal	2
Burning Of Waste	18
Pollution from other countries	9



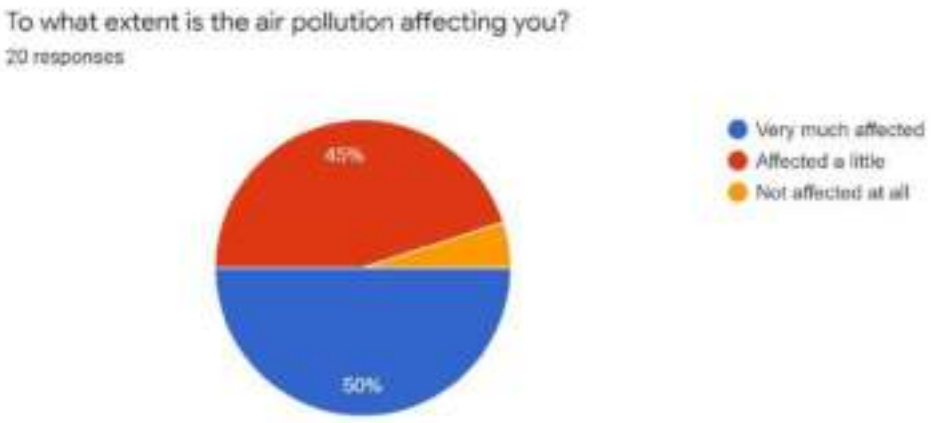
❖ **Interpretation:**

The survey of 20 different individuals was taken about the main causes of pollution in their cities. According to the analysis the top 5 main causes for the air pollution are **[Burning of waste (90%), Construction (65%), Motor Vehicles (60%), Industrial Sources (55%), Population growth (50%)],** which conveys that Burning of waste is the biggest reason due to which the pollution has increased in such a drastic level.

3. To what extent is the air pollution affecting you?

Primary Data Table-1.3

To what extent is the air pollution affecting you?	
Responses	**Data**
Very much affected	10
Affected a little	9
Not affected at all	1
Total	20



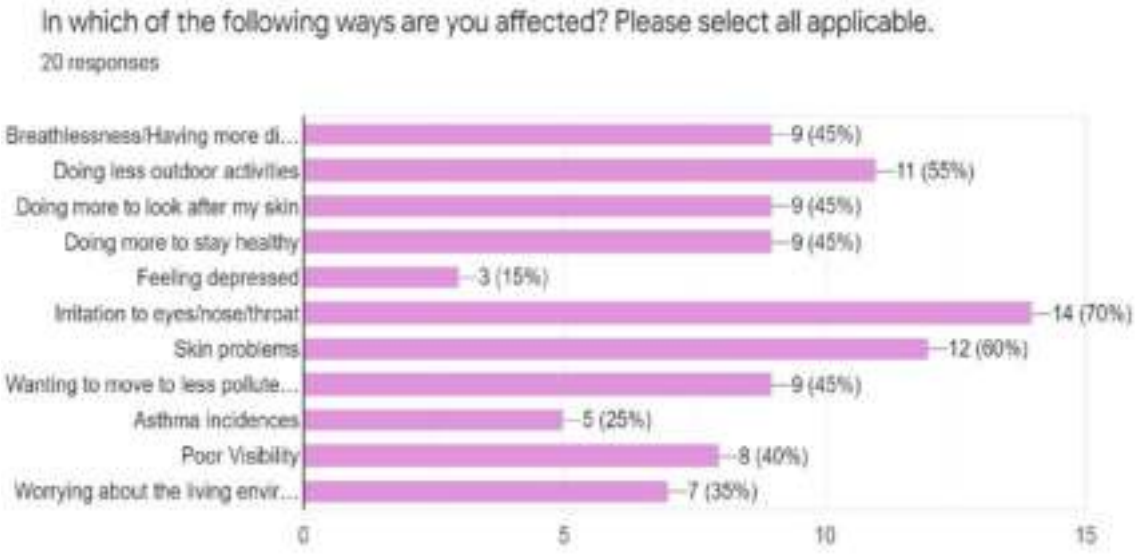
❖ Interpretation:

The survey of 20 different individuals was take about how the air pollution has been affecting them. According to the analysis **[Very much affected (10), Affected a little (9), Not affected at all (1)],** which conveys that most of the people were very much affected by the pollution in their city.

4. In which of the following ways are you affected? Please select all applicable

Primary Data

In which of the following ways are you affected? Please select all the applicable.	
Responses	**Data**
Breathlessness/Having more difficulty in breathing	9
Doing less outdoor activities	11
Doing more to look after my skin	9
Doing more to stay healthy	9
Feeling depressed	3
Irritation to eyes/nose/throat	14
Skin problems	12
Wanting to move to less polluted place	9
Asthma incidences	5
Poor Visibility	8
Worrying about the living environment for children	7



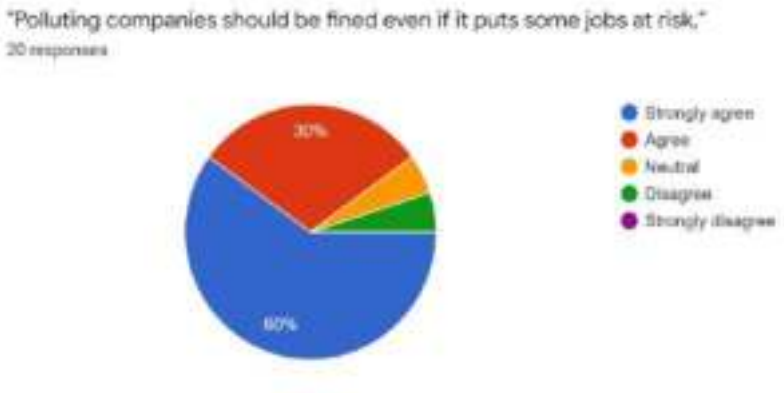
❖ **Interpretation:**

The survey of 20 different individuals was taken about in how many ways are they affected by the air pollution. According to the analysis the top 7 ways in which the people are affected by the air pollution are **[Irritation of eyes/noes/throat (70%), Skin problems (60%), Doing less outdoor activities (55%), Breathlessness / having more difficulty in breathing (45%), Doing more to look after my skin (45%), Doing more to stay healthy (45%), Wanting to move to a less polluted city (45%)].**

5. **"Polluting companies should be fined even if it puts some jobs at risk," * Please express how much do you agree or disagree on the given statements**

Primary Data: Table-1.5

"Polluting companies should be fined even if it puts some jobs at risk,"	
Responses	**Data**
Strongly Agree	12
Agree	6
Neutral	1
Disagree	1
Strongly Disagree	0
Total	20



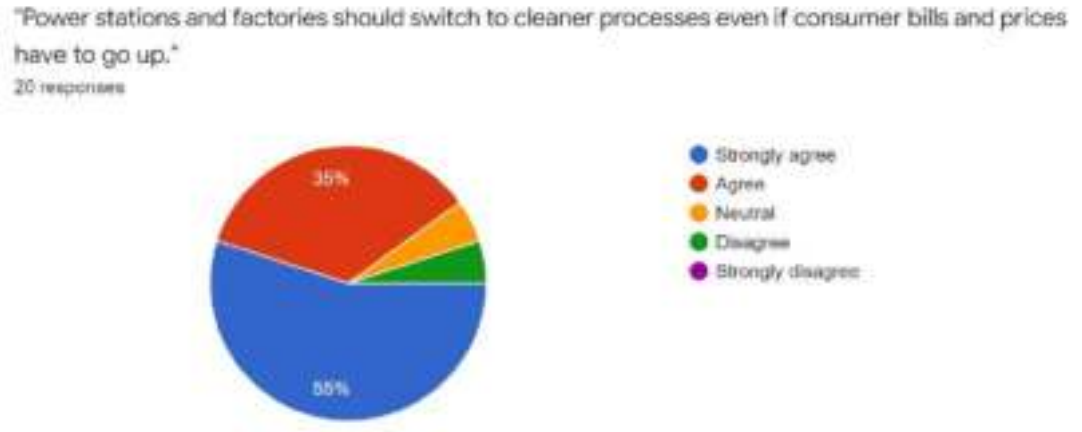
❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether the polluting companies should be fined even if it puts some jobs at risk. According to the analysis **[Strongly Agree (12), Agree (6), Neutral (1), Disagree (1), Strongly Disagree (0)],** which conveys that that most of the people strongly agree with the fact.

6. **"Power stations and factories should switch to cleaner processes even if consumer bills and prices have to go up." * Please express how much do you agree or disagree on the given statements.**

Primary Data: Table-1.6

"Power stations and factories should switch to cleaner processes even if consumer bills and prices have to go up."	
Responses	**Data**
Strongly Agree	11
Agree	7
Neutral	1
Disagree	1
Strongly Disagree	0
Total	20



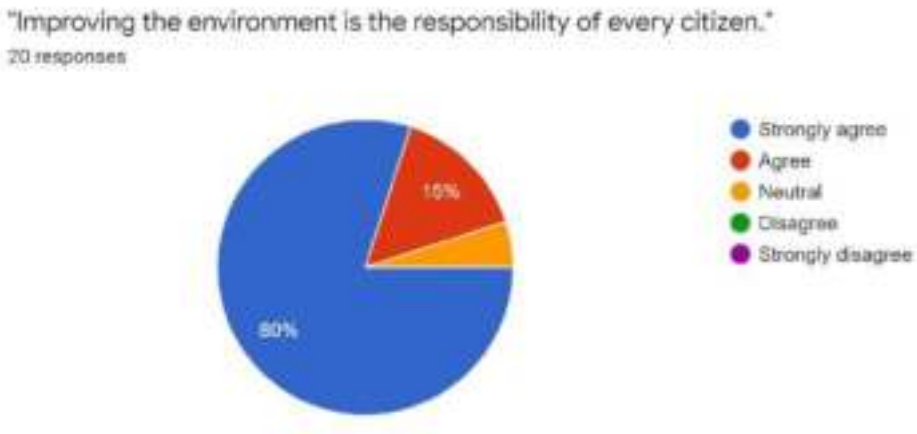
❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether according to the analysis power stations and factories should switch to cleaner processes even if consumer bills and prices have to go up **[Strongly Agree (11), Agree (7), Neutral (1), Disagree (1), Strongly Disagree (0)],** which conveys that that most of the people strongly agree with the fact.

7. **"Improving the environment is the responsibility of every citizen." * Please express how much do you agree or disagree on the given statements.**

Primary Data: Table-1.7

"Improving the environment is the responsibility of every citizen."	
Responses	**Data**
Strongly Agree	16
Agree	3
Neutral	1
Disagree	0
Strongly Disagree	0
Total	20



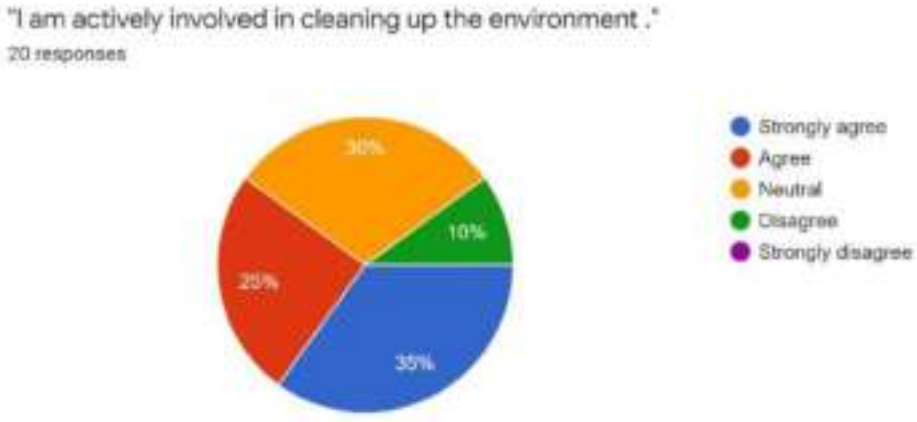
❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether according to the analysis improving the environment is the responsibility of every citizen **[Strongly Agree (16), Agree (3), Neutral (1), Disagree (0), Strongly Disagree (0)],** which conveys that that most of the people strongly agree with the fact.

8. **"I am actively involved in cleaning up the environment ." * Please express how much do you agree or disagree on the given statements.**

Primary Data: Table-1.8

" I am actively involved in cleaning up the environment."	
Responses	**Data**
Strongly Agree	7
Agree	5
Neutral	6
Disagree	2
Strongly Disagree	0
Total	20



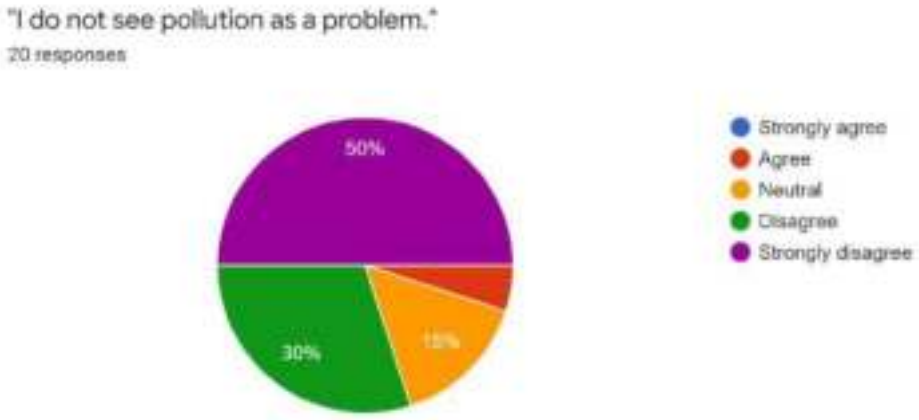
❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether they are actively involved in cleaning up the environment. According to the analysis **[Strongly Agree (7), Agree (5), Neutral (6), Disagree (1), Strongly Disagree (0)],** which conveys that that most of the people agree with the fact.

9. **"I do not see pollution as a problem." * Please express how much do you agree or disagree on the given statements.**

Primary Data: Table-1.9

" I do not see pollution as a problem."	
Responses	**Data**
Strongly Agree	0
Agree	1
Neutral	3
Disagree	6
Strongly Disagree	10
Total	20



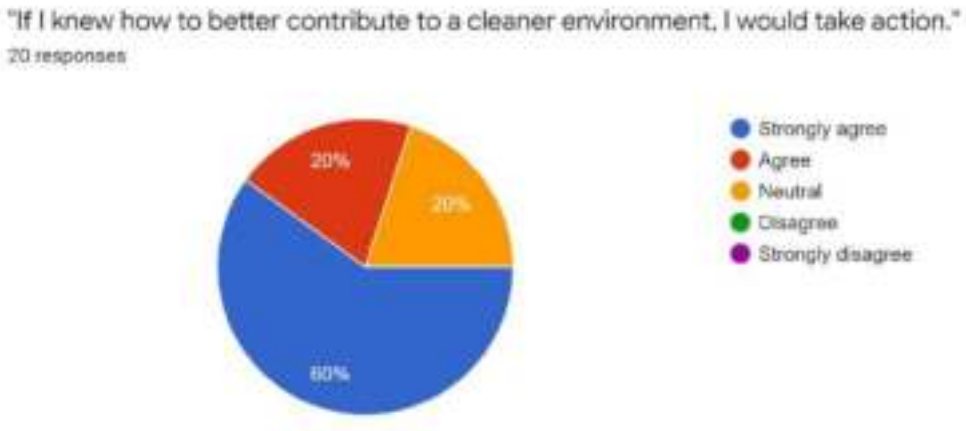
❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether they do not see pollution as a problem. According to the analysis **[Strongly Agree (0), Agree (1), Neutral (3), Disagree (6), Strongly Disagree (10)],** which conveys that that most of the people agree with the fact.

10."If I knew how to better contribute to a cleaner environment, I would take action." * Please express how much do you agree or disagree on the given statements.

Primary Data: Table-1.10

" I am actively involved in cleaning up the environment."	
Responses	**Data**
Strongly Agree	12
Agree	4
Neutral	4
Disagree	0
Strongly Disagree	0
Total	20



❖ **Interpretation:**

The survey of 20 different individuals was taken about the fact that whether if they knew how to better contribute to a cleaner environment, they would take action. According to the analysis **[Strongly Agree (12), Agree (4), Neutral (4), Disagree (0), Strongly Disagree (0)],** which conveys that that most of the people agree with the fact.

Findings & Conclusions

An effective and successful emission control strategy should be holistic (Molina, Molina, Slott, et al. 2004). It must be a combination of successfully applied scientific ideas and technological advancements; should support the economy and be supported by the public. Various steps taken by the Government of India to control air pollution in Indian cities have been highlighted in the previous sections. These measures have the potential to tackle pollution only if implemented successfully in the coming years.

India is facing serious issues of poor air quality in many urban areas. Apart from the much discussed megacities, like Delhi, various reports suggest that several medium-scale cities are equally at the brunt of filthy air. The ill-effects could impact human health in a negative way, also affecting the biodiversity, other life forms, heritage, cultural buildings and even climate in the longer term. It is about time that the government comes forward to support cities for the development of infrastructure and treatment facilities.

It is also derived from the study about how much awareness the people have about the harmful effects of the environment and also about how the situation can be improved but still the current situation of the environment is so disastrous that it might take several years to retain the environment the way it should be.

The control strategies adopted to tackle air pollution must be sustainable in nature. For example, the urban air pollution control strategy should depend mainly on sustainable means of public transportation modes, such as BRTs, metros, trams, cycle lanes and well-connected pedestrian facilities, which can further ensure minimum use of private vehicles, thereby reducing air pollution levels. People must be motivated to opt for an efficient public transport system instead of relying on private vehicles. Similarly, some strict laws must be enforced, such as emission trading and congestion pricing, which have the potential to reduce emissions drastically. Apart from these, the use of alternate fuels and e-cars, e-bikes and hybrid vehicle types must be promoted by the government. All these measures could reduce city emissions significantly.

The residents of rural areas are seldom aware of the harmful effects of air-borne pollutants and their consequence to human health. Public awareness programmes should be initiated by the government in every city, both rural and urban, highlighting the importance of managing air pollution at source and the various control measures that could be adopted to reduce pollutant emissions. Such initiatives could significantly reduce the activities, such as open burning of wastes, crop burning, use of biomass as a fuel for cooking and burning of plastic and rubber materials during winters. A holistic approach incorporating all of the mentioned measures could be beneficial to attain cleaner air quality in Indian cities and guarantee a healthier place to inhabit.

In this context, the NCAP launched by the Government of India appears to be a timely intervention. It is based on a long-term, time-bound, national-level strategy to tackle air pollution in a comprehensive manner with targets to achieve 20–30% reduction in particulate matter (PM) concentrations by 2024, keeping 2017 as the base year for the comparison of concentration levels. A total of 122 non-attainment cities have been identified across the country based on the 'Air Quality' data obtained for the period 2014–2018 under NCAP. The city-specific action plans are being prepared which, inter-alia, include measures for strengthening the monitoring network, developing emission inventories, carrying out source apportionment studies, reducing vehicular/industrial emissions, and generating public awareness, among others. It is expected that such initiatives by the central and state governments along with the participation of local bodies and other stakeholders comprising academia, research institutions, and public interest groups would result in ensuring better air quality in India.

Suggestions & Recomendations

Urgent actions are required to help reduce air pollution in Delhi, one of the most polluted cities in the world, and restore various air parameters to levels safe for the health of its citizens and visitors. Here are few steps that can play an instrumental role in reducing air pollution in Delhi, which reached alarming levels of 485 AQI (air quality index), when the safe limit for humans is less than 100 AQI.

1. Car pooling: Reduce traffic-based air pollution and congestion by starting car pool lanes for those cars and four wheelers that have three or more passengers to encourage people to go for car pooling. Meanwhile, citizens too should take initiative and car pool with friends, colleagues, family wherever possible.

2. Use bicycles: Mark out bicycle lanes in residential colonies as well as on all roads in Delhi to encourage safe travel by bicycles. Meanwhile, citizens should also be encouraged to use bicycles.

3. Public transport: Encourage greater use of public transport by supporting the Metro, overhead rail and bus services to make it convenient for people to travel by public transport affordably and safely instead of using their own vehicles. Citizens too must shed hang-ups over social status and try to travel by public transport proactively.

4. More CNG vehicles: Encourage use of CNG in motor vehicles as it is a much cleaner fuel than petrol or diesel by considerably reducing the road tax and sales tax on CNG filled cars as compared to petrol and diesel four wheelers. Since there are at least 1,400 cars added to Delhi roads every day, all the cars should be restricted to using CNG only as all new petrol cars can be converted to CNG. Also, new registrations should be discouraged by enhancing registration charges.

5. Fuel-efficient cars: Encourage more fuel efficient four wheelers with better mileage per litre through road tax and sales tax incentives in addition to CNG requirement.

Citizens should opt for more efficient and smaller cars that can run on CNG as alternate fuel.

6. Bigger trucks: Encourage six-axle trucks rather than the typical four-axle ones to increase the pay load per truck to reduce the number of trucks on roads. Trucks going to other destinations must not be allowed to pass through Delhi and only use the bypass.

7. Road signs: Improve the poor road signs so that people do not travel extra to locate their destinations. All the signs must be signposted at two or three places well before the turning rather than at the last minute.

8. Maintenance of roads: Better maintain roads to complexes such as Nehru Place to reduce the time a four wheeler spends on plying on such poor roads.

9. Shared taxis: The transport department should encourage shared taxi services by developing a taxi sharing website and set up taxi stands and cabs to offer reduced fares for shared service. This is other than the facilities Ola and Uber provide.

10. Burning waste: Burning of leaves, old tyres or any items in the open should be made a punishable offence in NCR with a fine of Rs 10,000 per incident as this is a major cause of air pollution. Citizens should be asked to report such incidents to helpline numbers and emails.

11. Solar power: Installation of solar panels should be encouraged at homes, multi-storey buildings and commercial establishments so that decentralised power is generated with suitable subsidies to make it financially viable for all households. The cost of solar panels has come down considerably. This should help retire all coal-based thermal power plants which are adding a lot to Delhi's air pollution problems and adversely effecting climate change. In fact, thermal power plants in Delhi-NCR should be stopped from functioning till the AQI level is under 200.

12. Power backup: Inverters should be encouraged for back up supply and diesel generator sets should not be allowed to run in Delhi-NCR till the AQI level comes below 200.

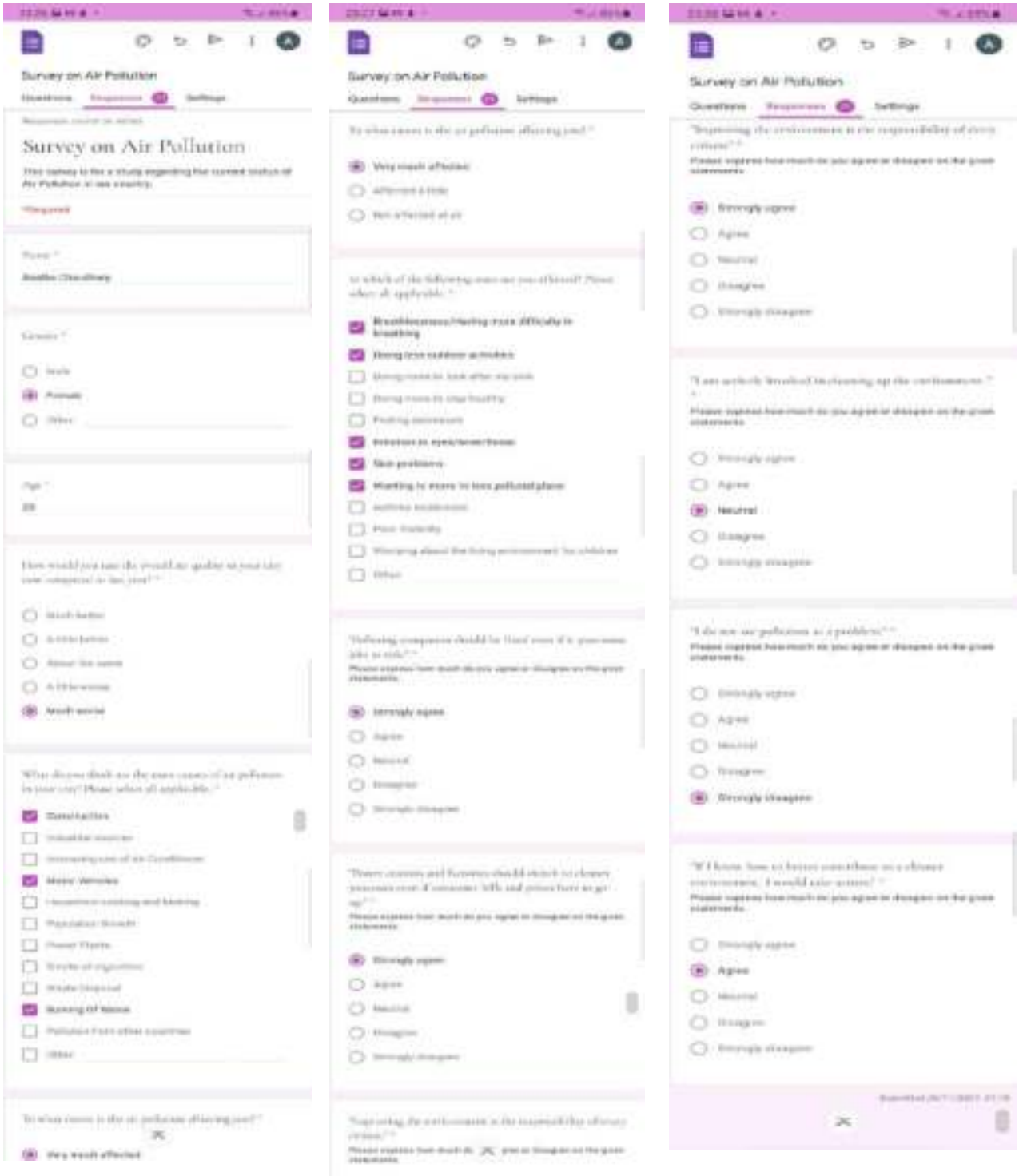
13. Dump sites: Landfills should be better managed by the government to ensure there are no fires there.

14. RO-RO on roads: The present RO-RO (Roll-on-Roll-off) scheme launched by Indian Railways to carry loaded trucks on goods train to decongest Delhi roads and to reduce air pollution needs to be given a fill up and made compulsory for trucks which otherwise pass through Delhi.

Annexures

Response Sheets

1st Response Sheet :



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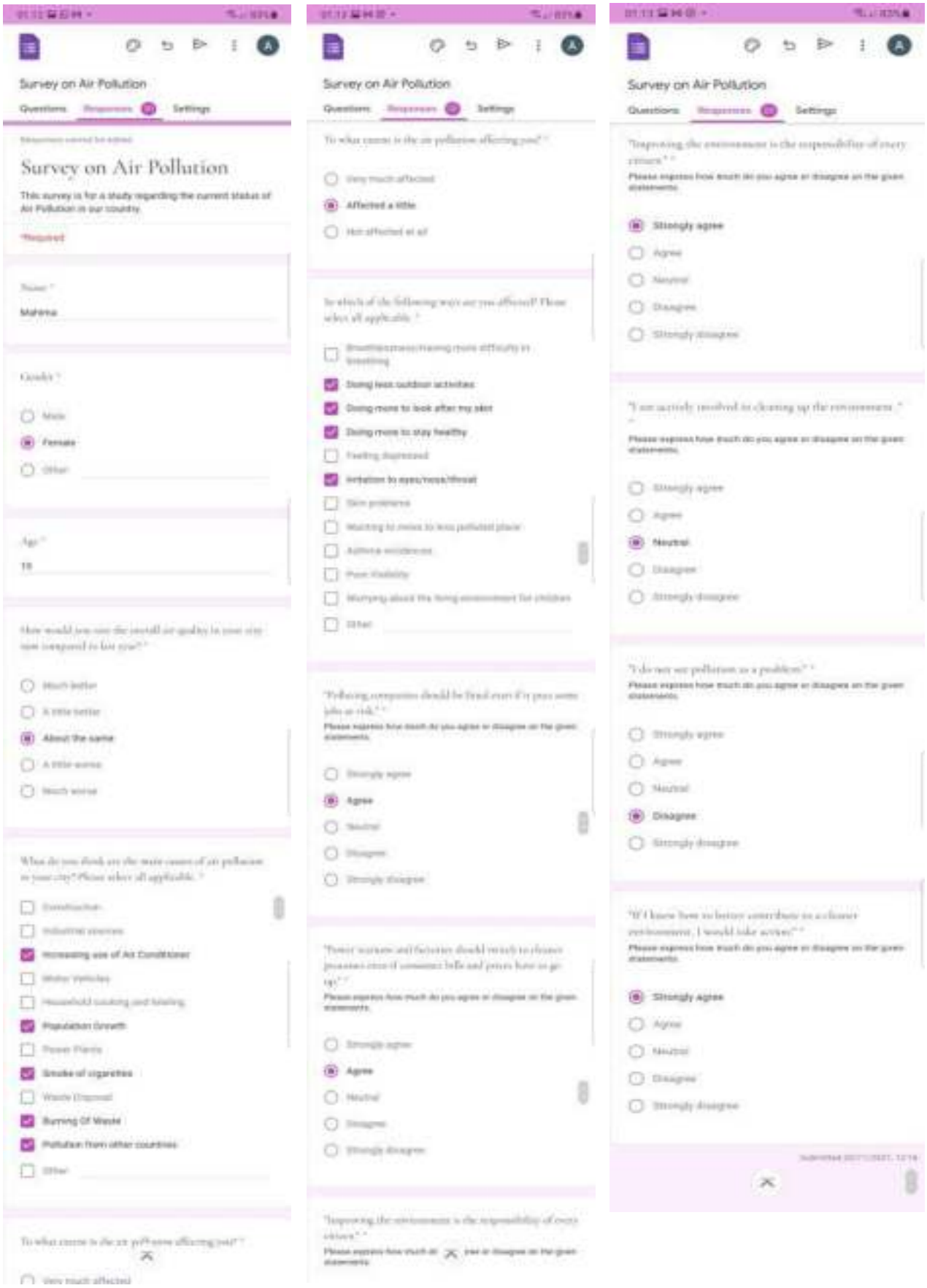

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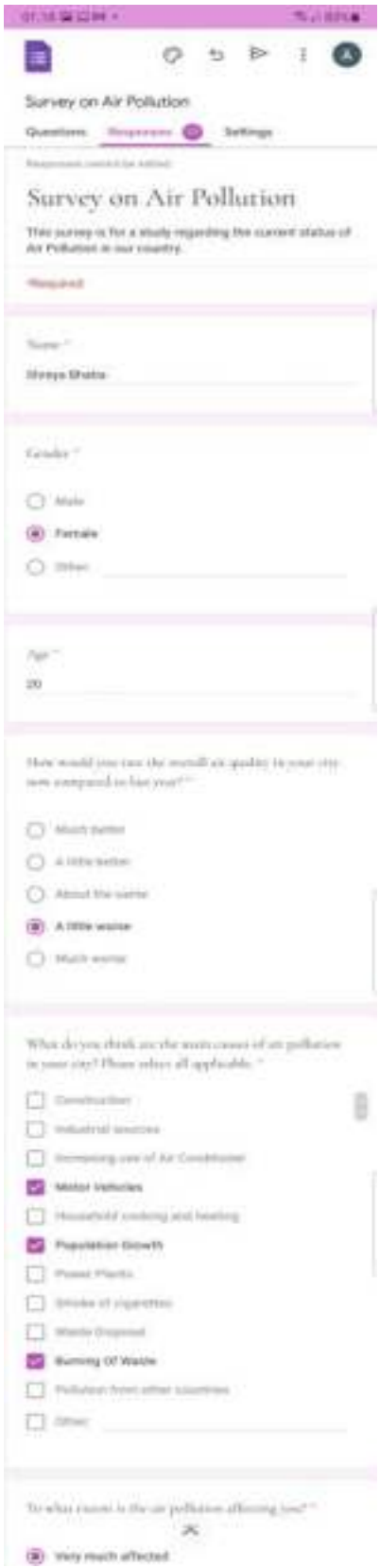

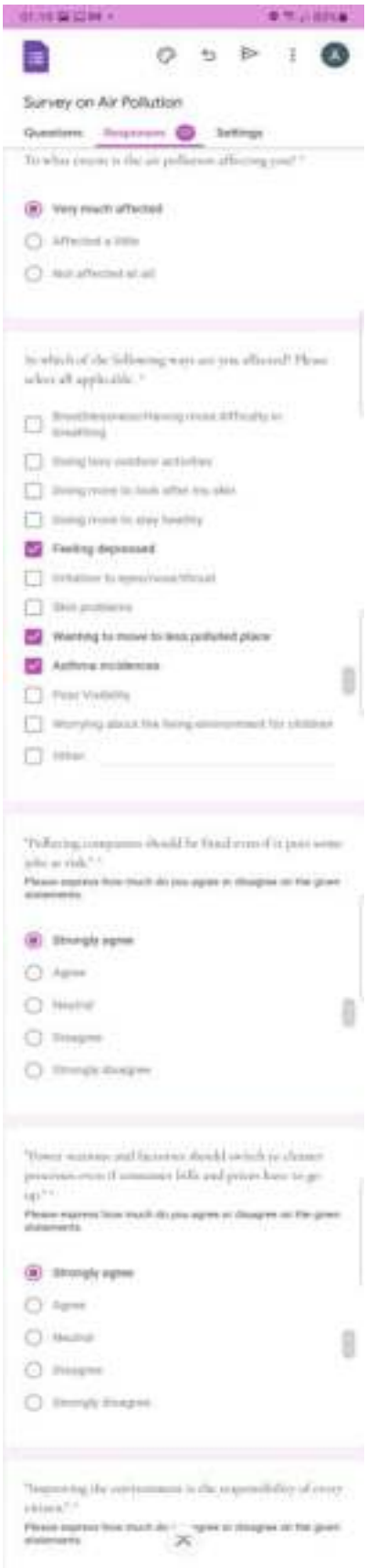

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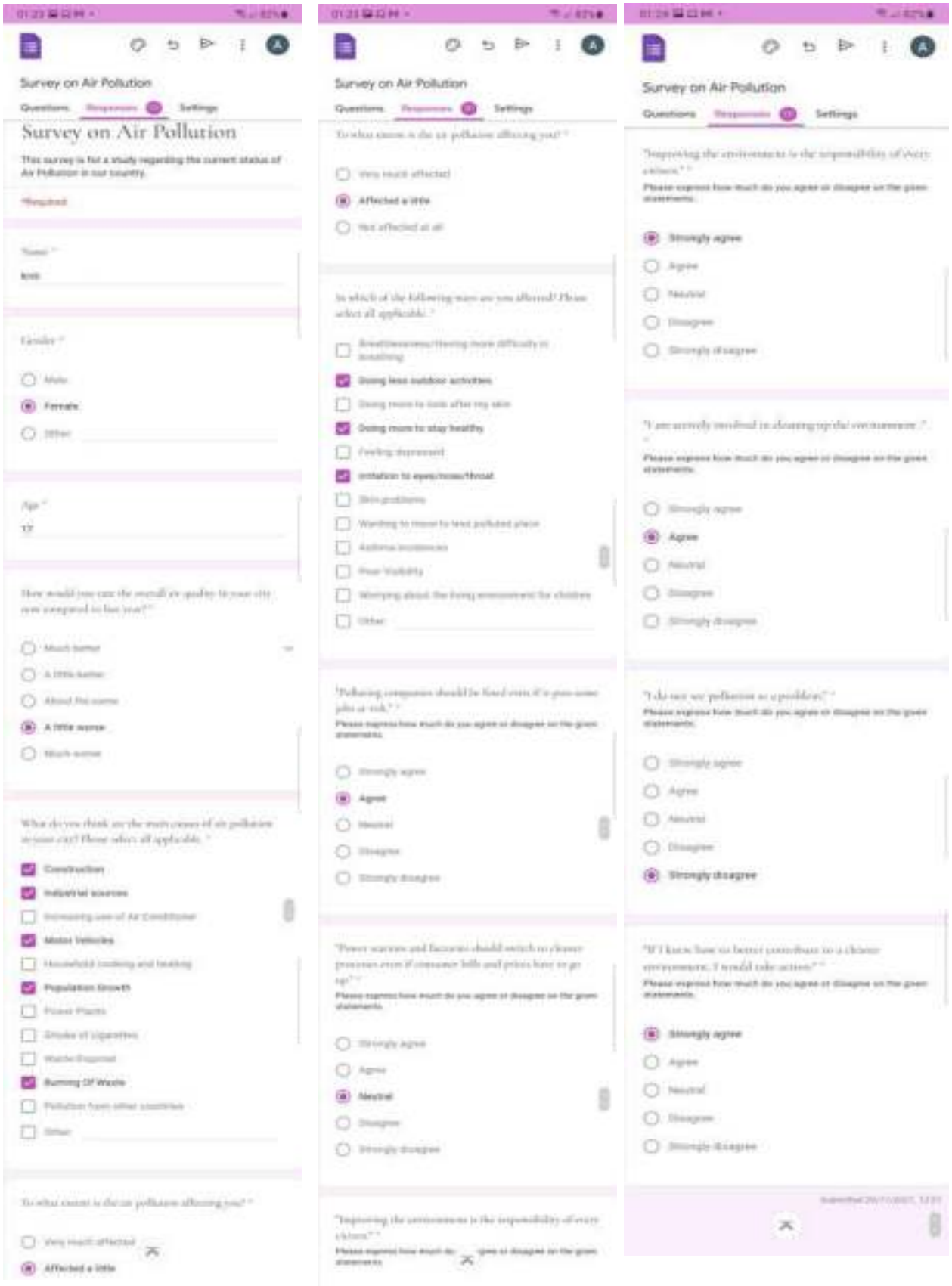

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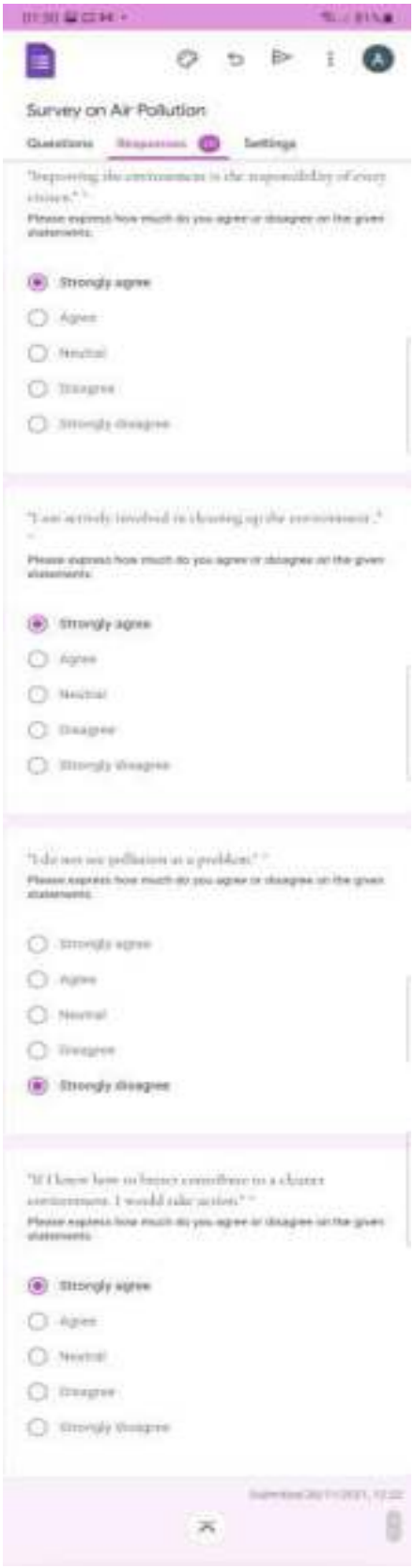

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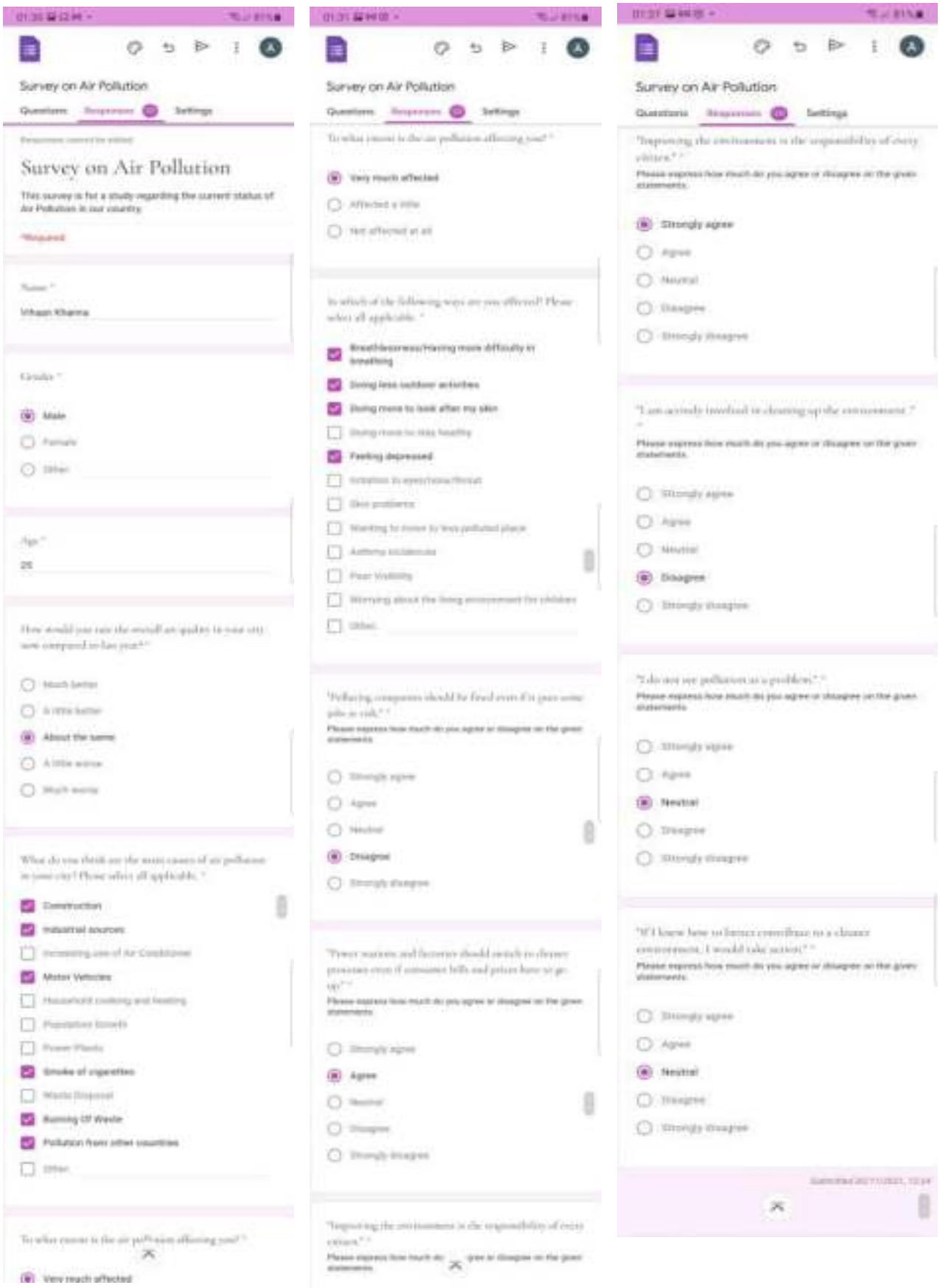

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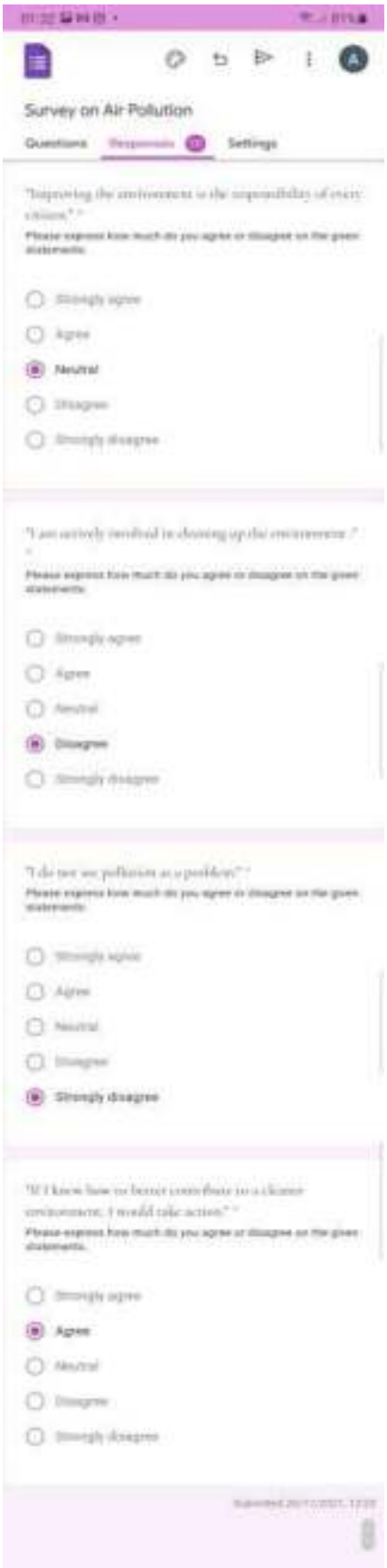

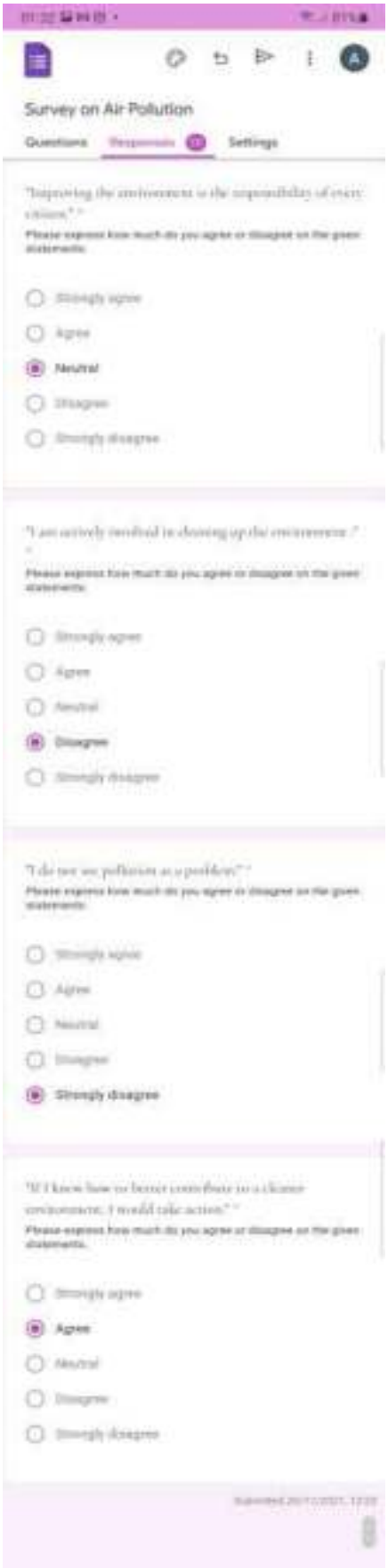

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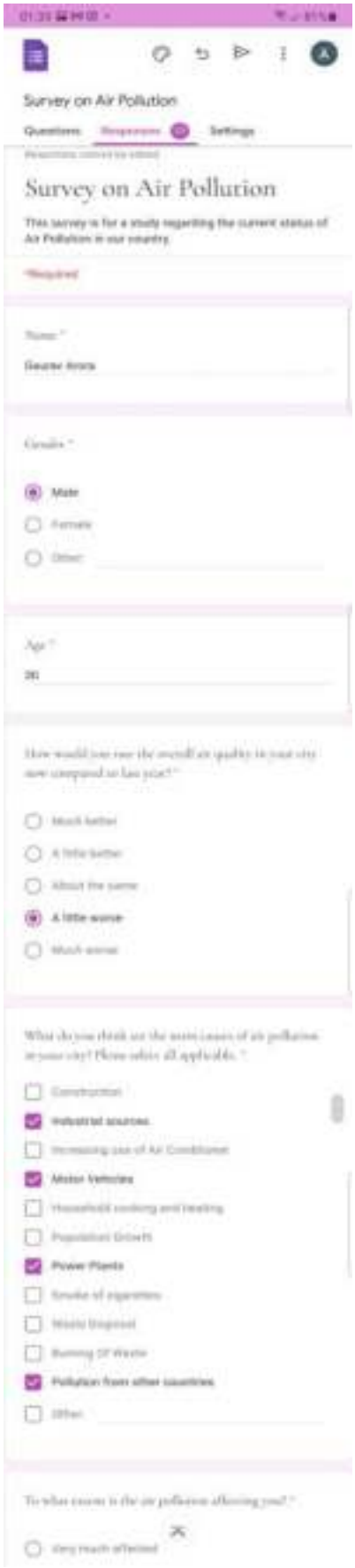

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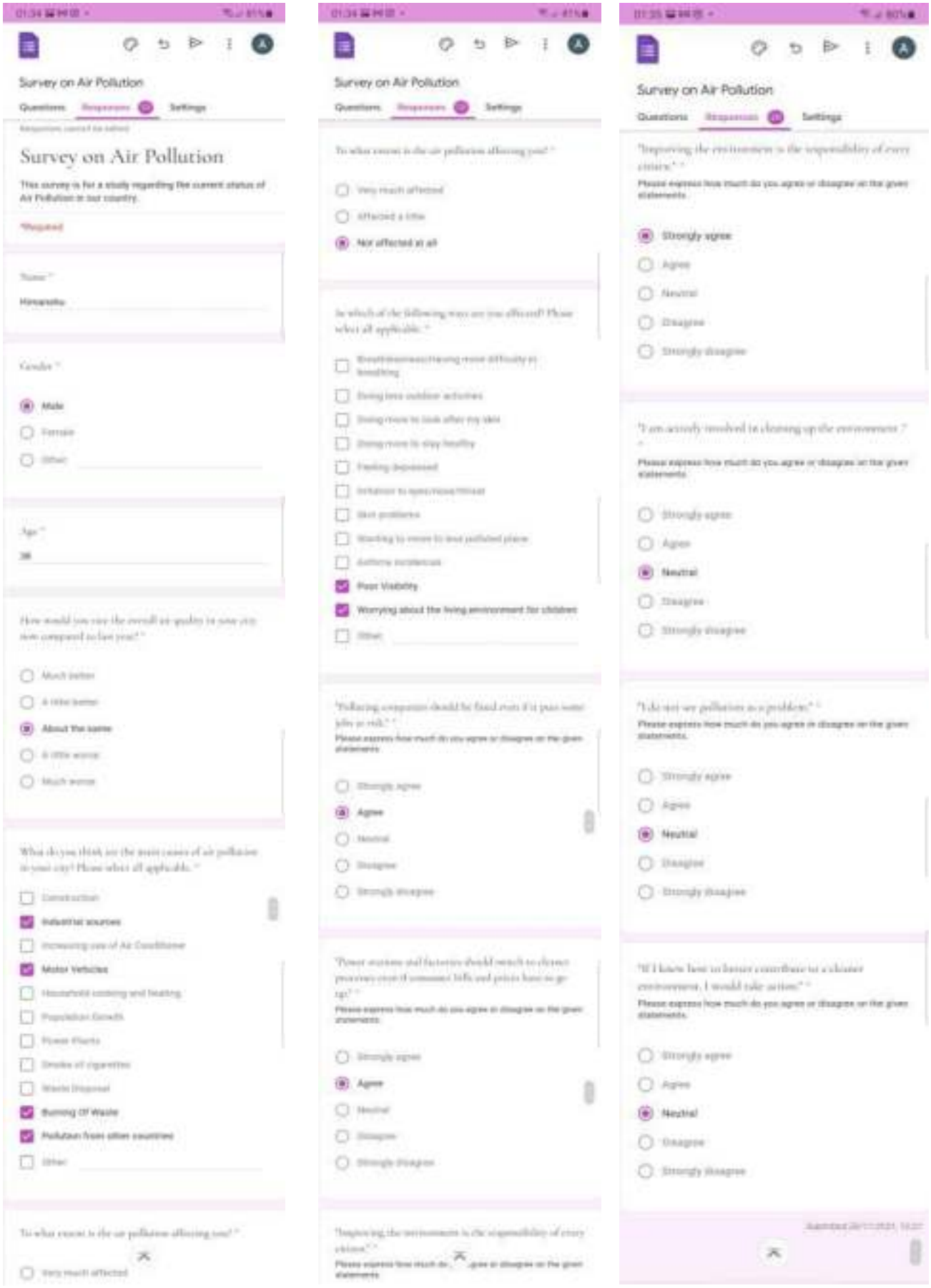

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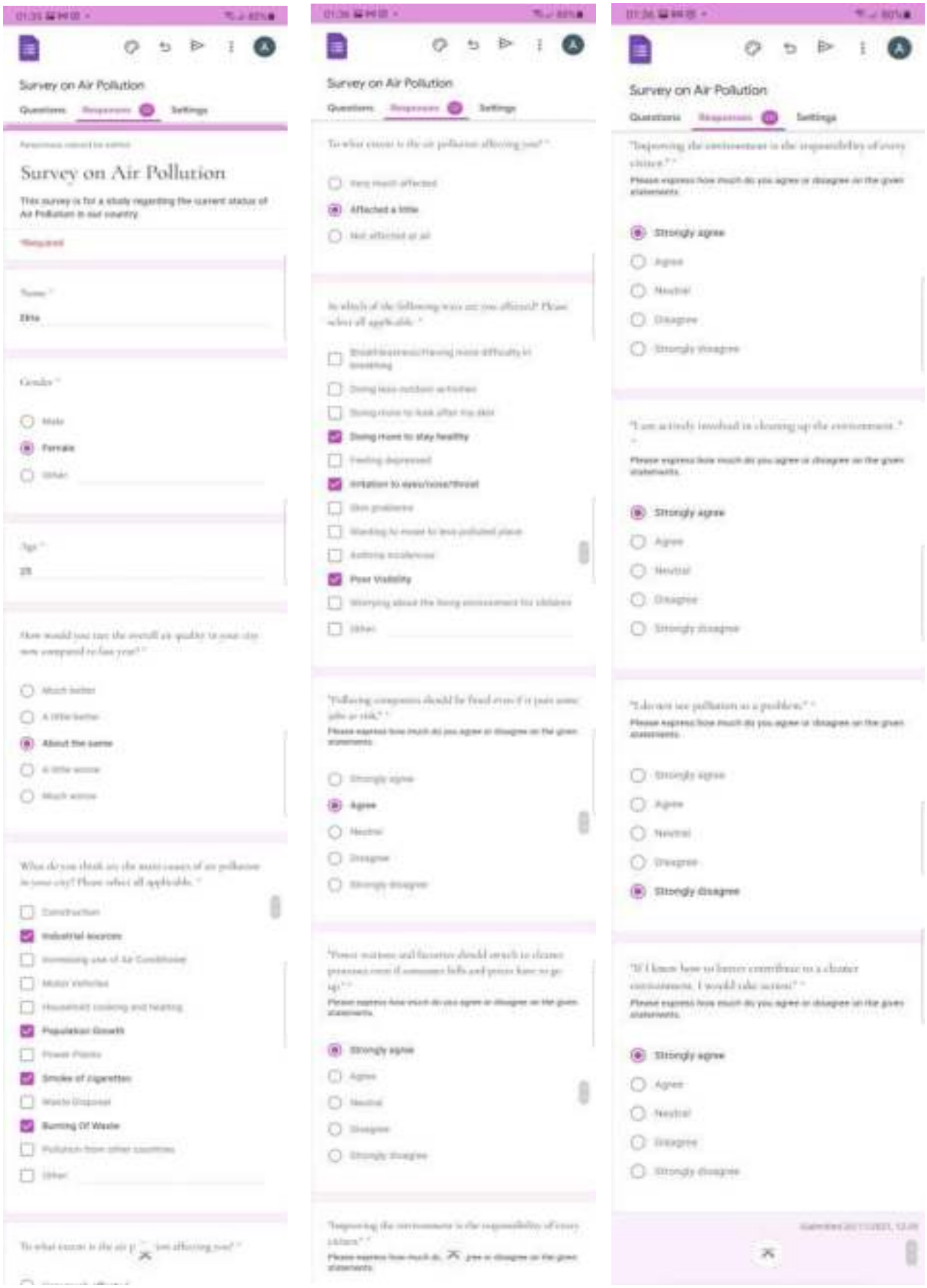

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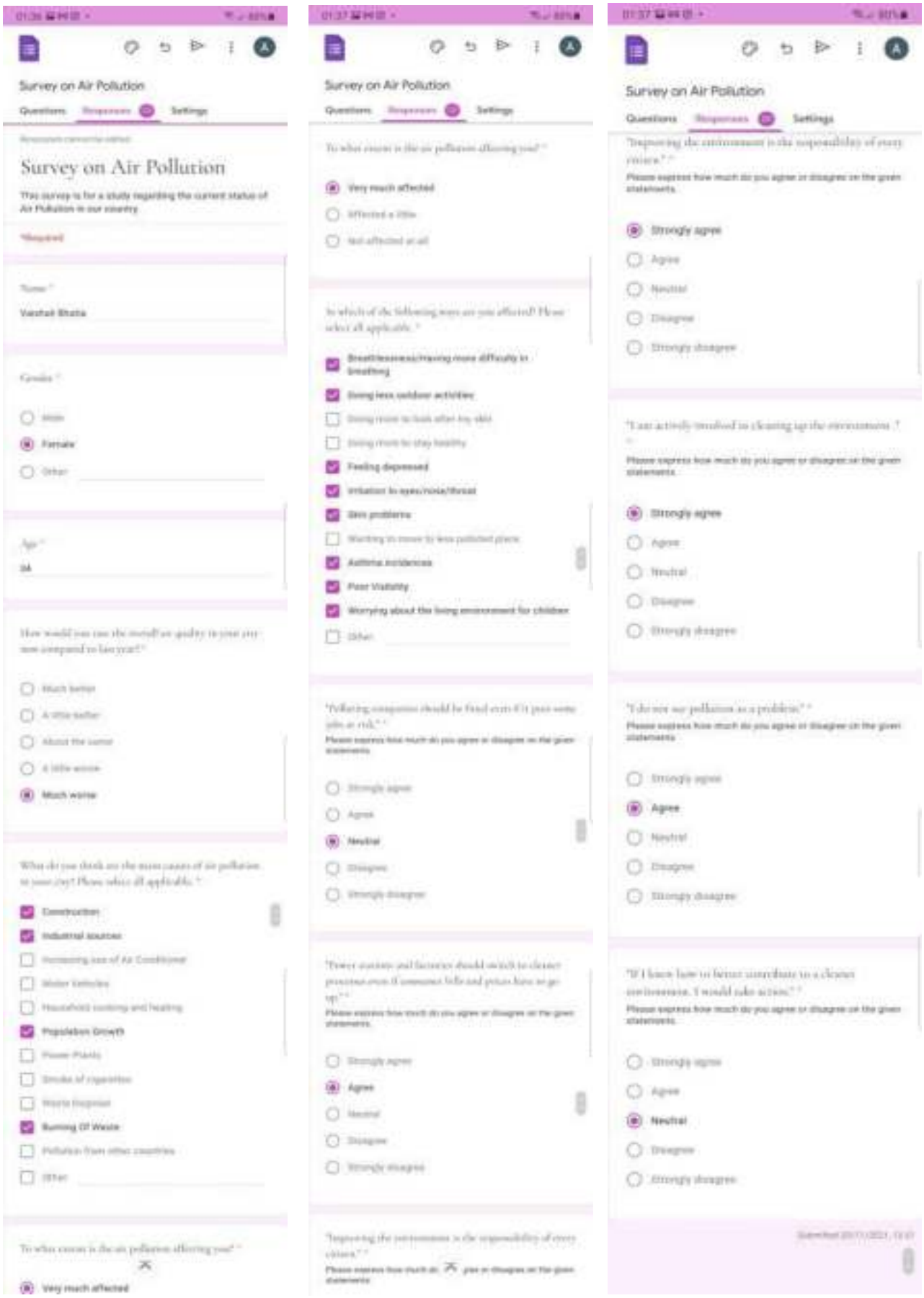

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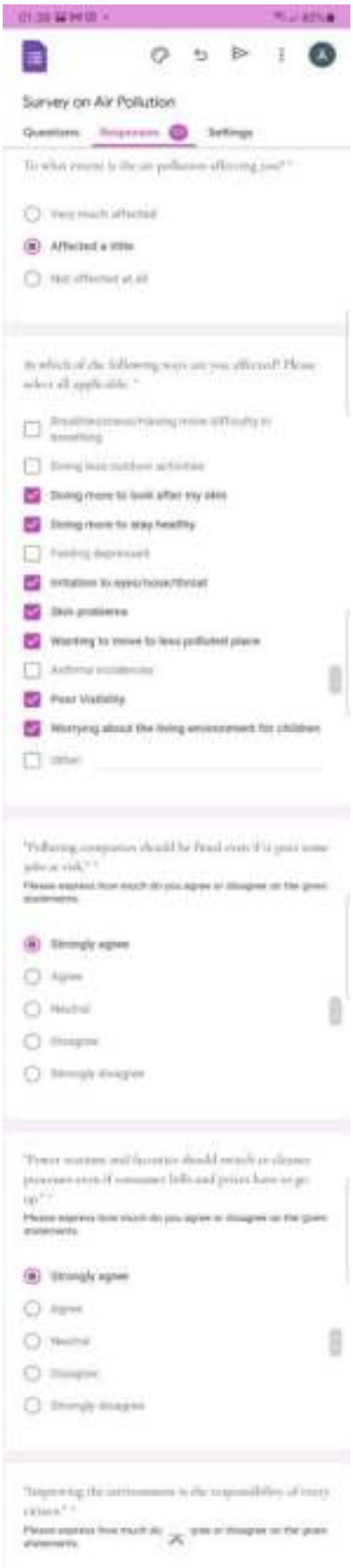

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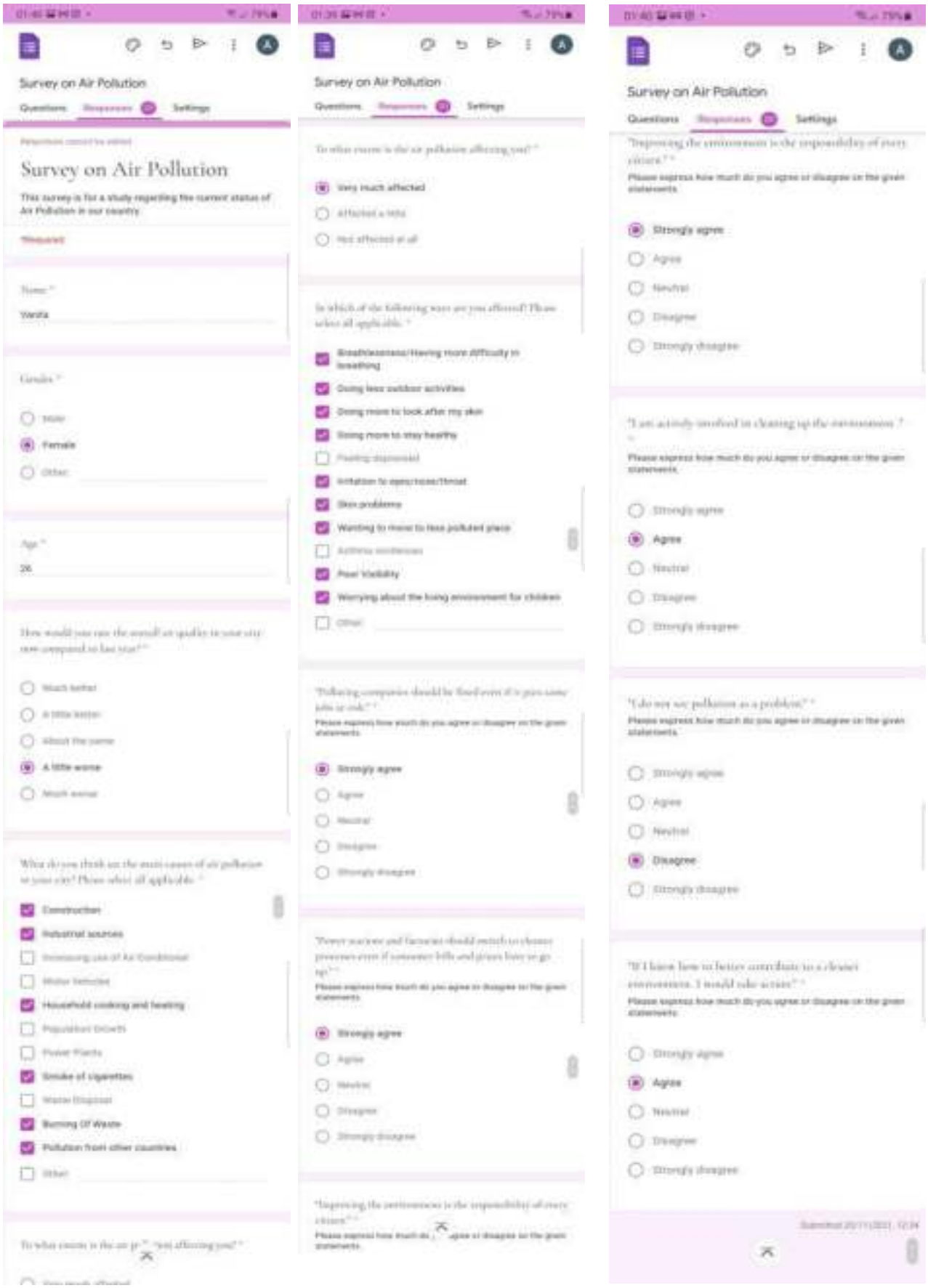

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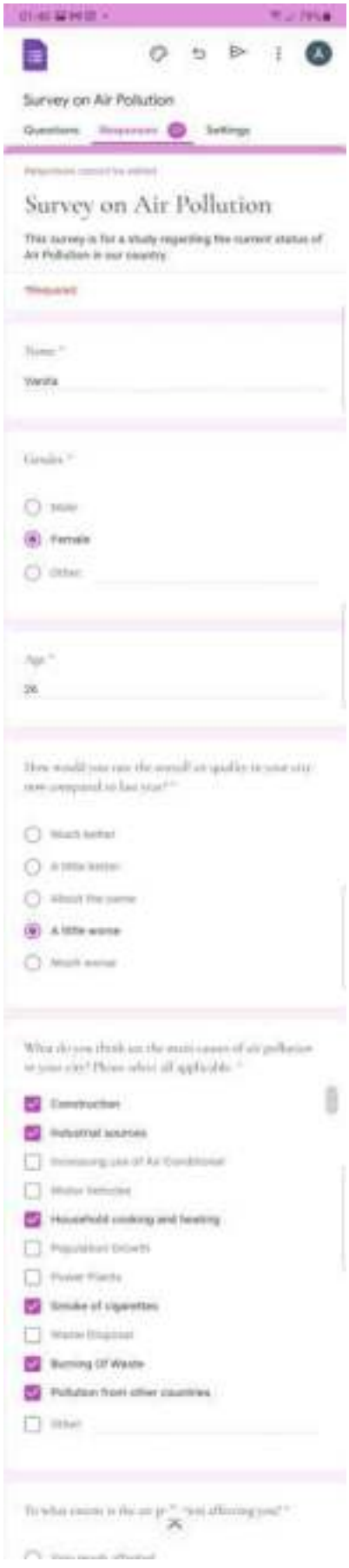

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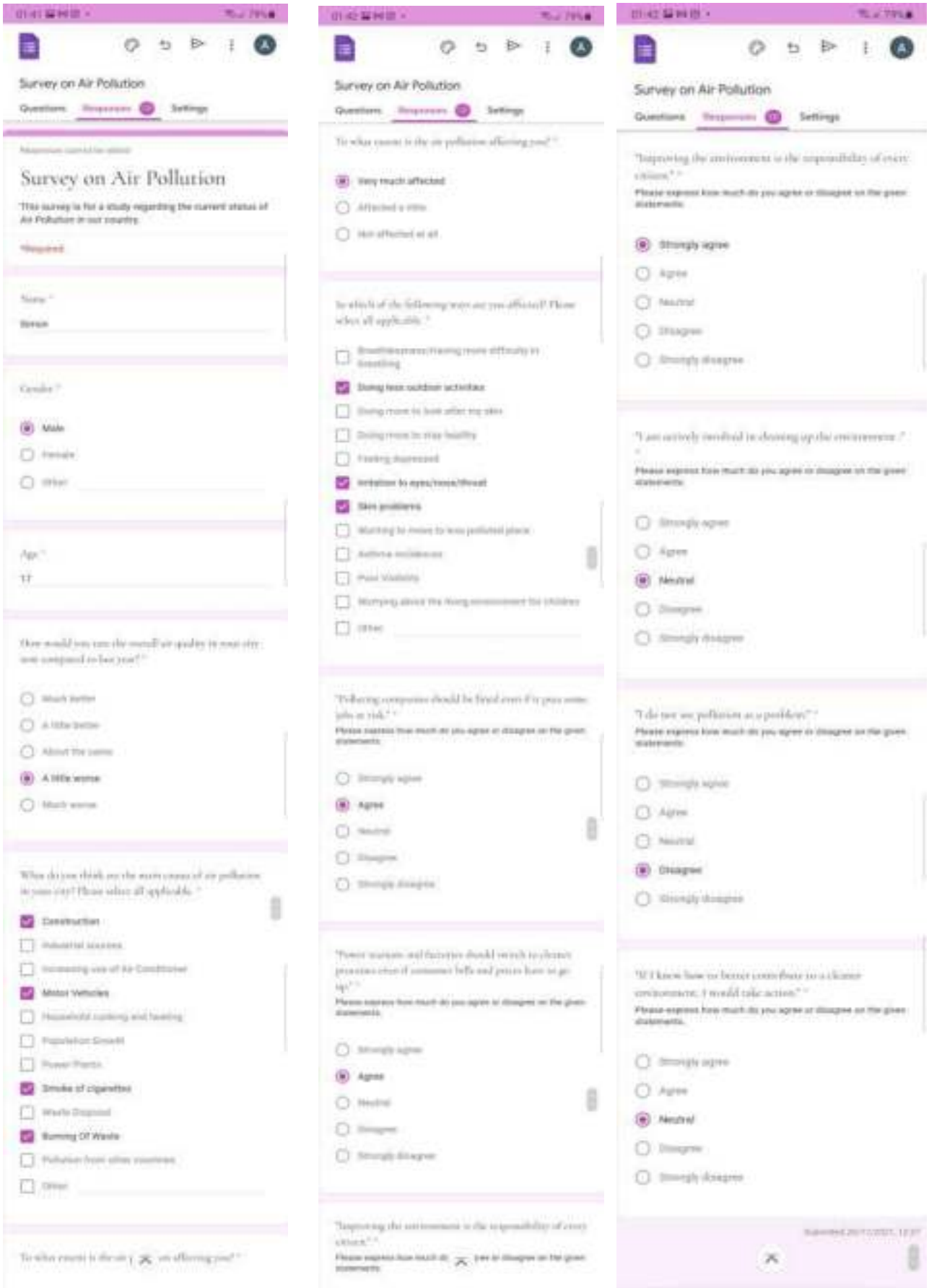

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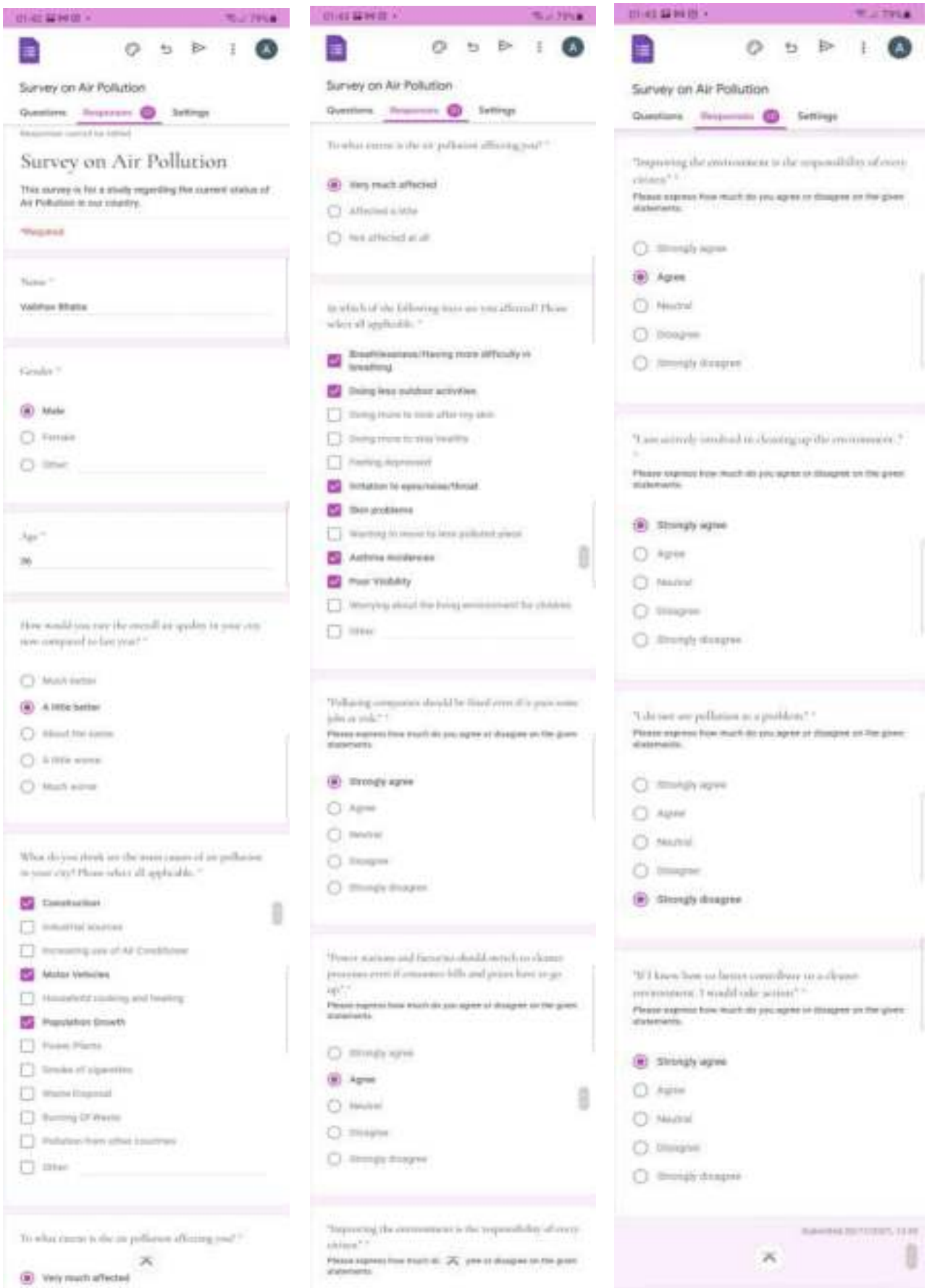

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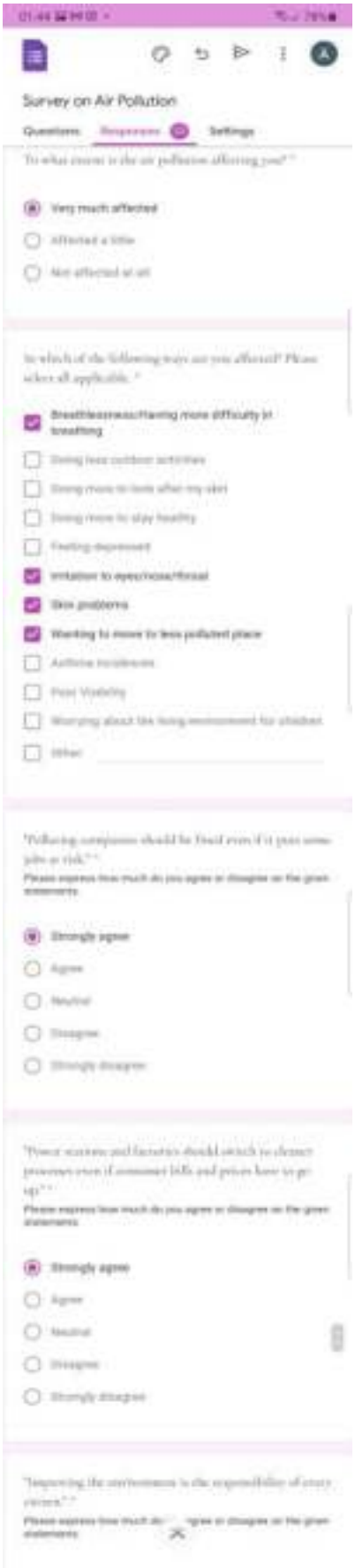

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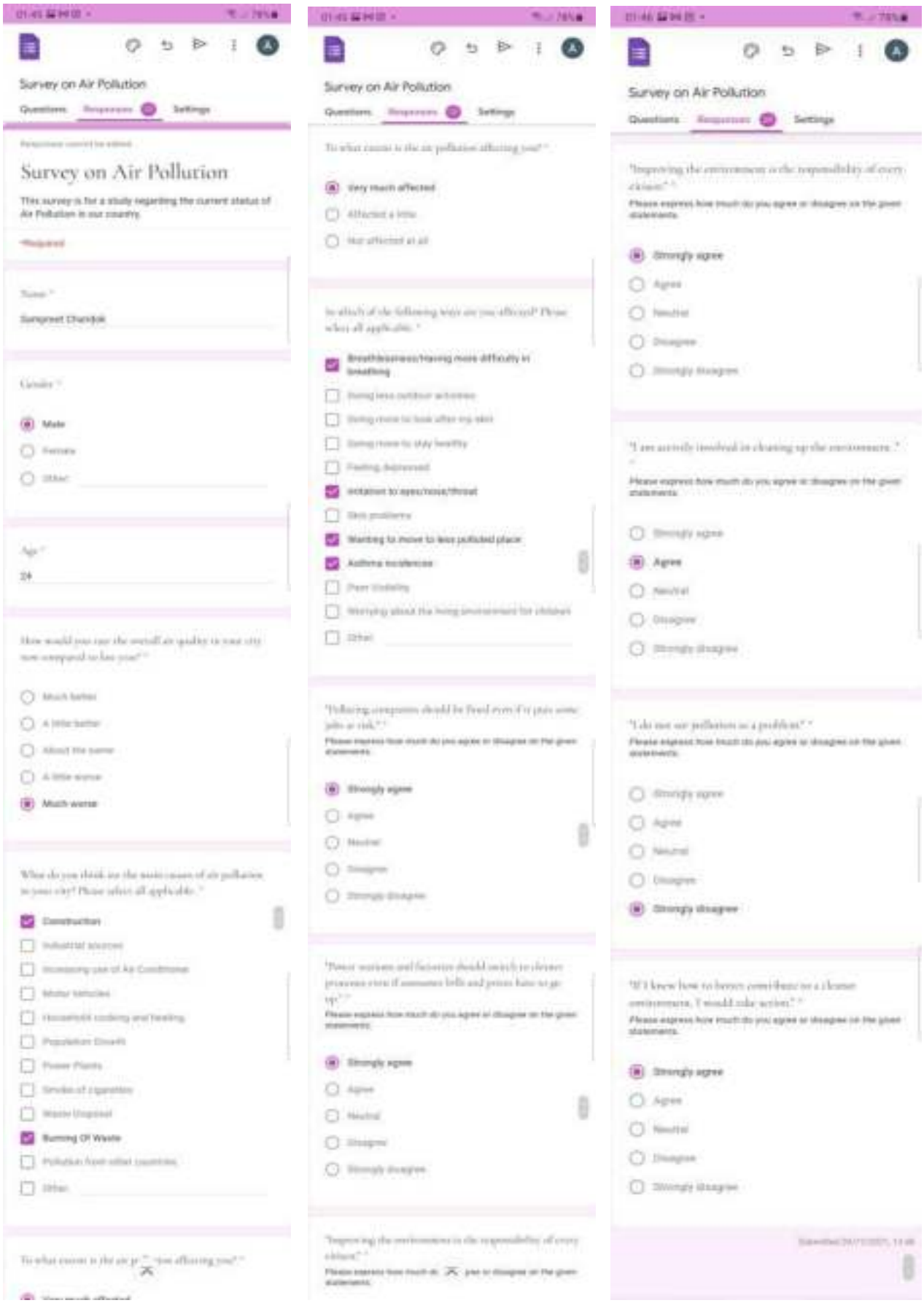

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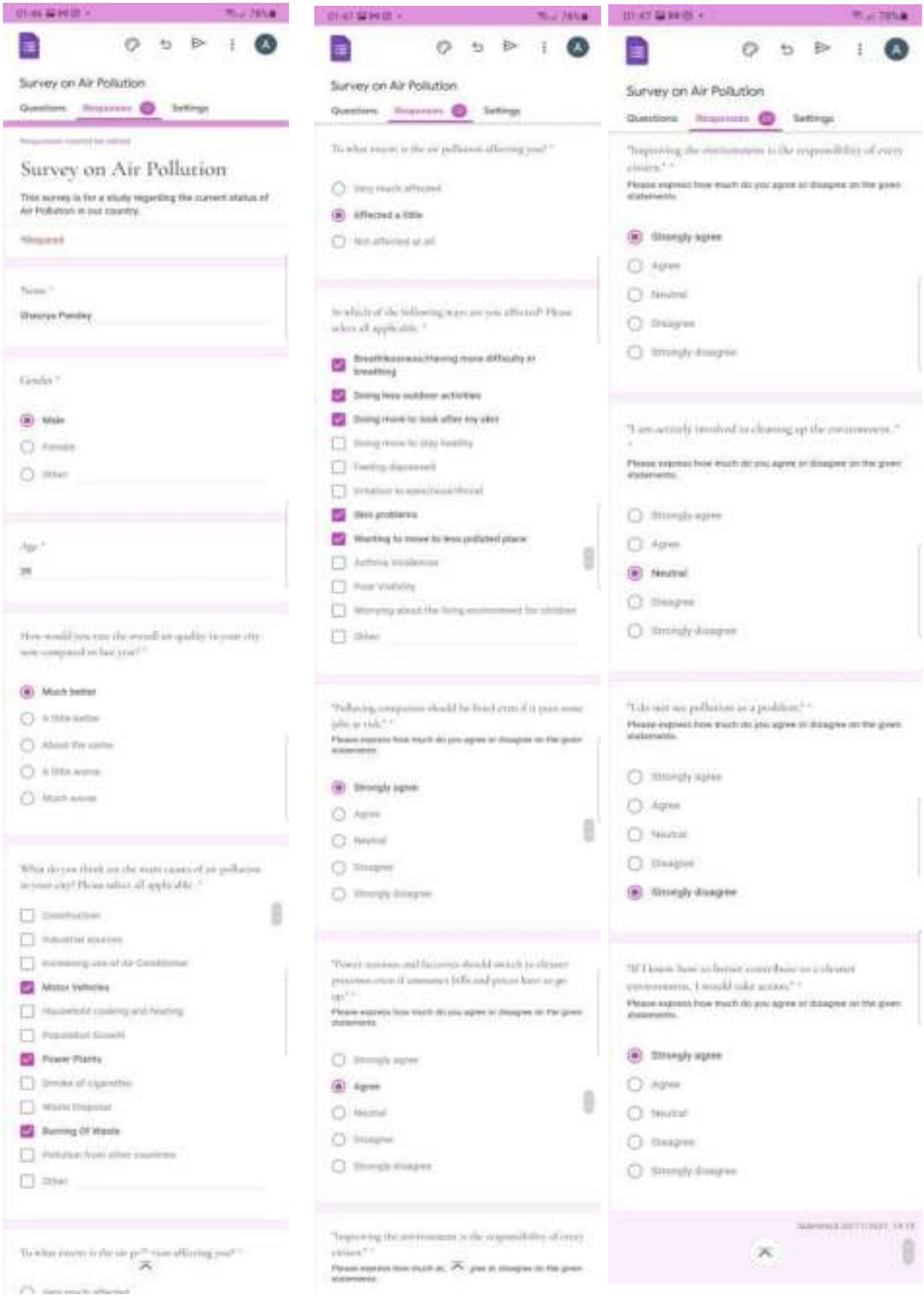

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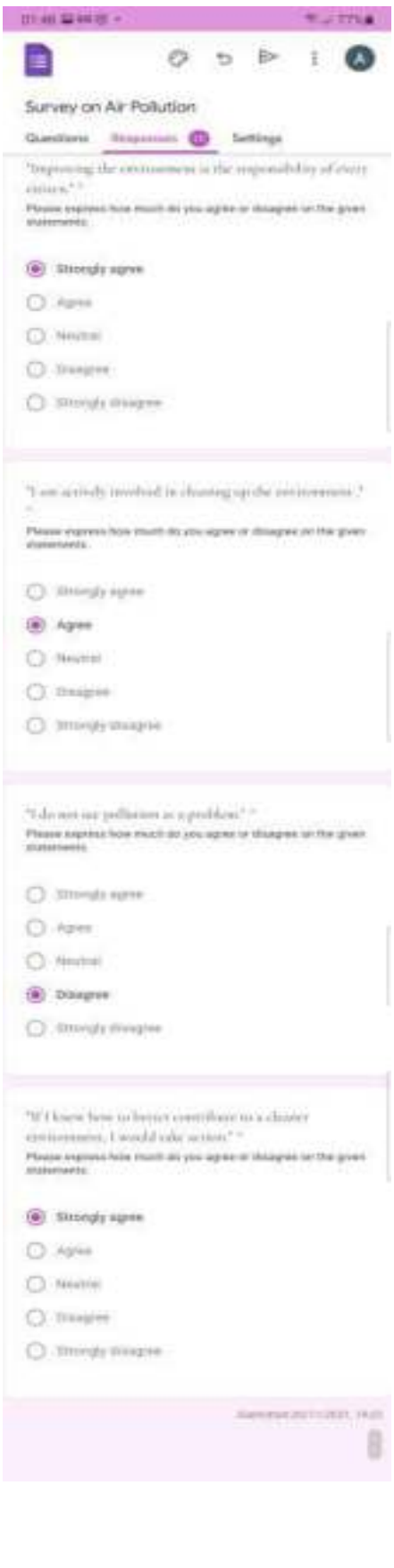

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