A COMPARATIVE STUDY OF DRONE EFFICACY FOR CONTAINING COVID -19

Agnishwar Jayaprakash[1], Chandravadhana[2], Kannappan[3]

[1]Aerospace Engineering, Agni College of Technology
[2]Mechatronics Engineering, Agni College of Technology
[3]Research and Development, M.S.Swaminathan Research Foundation

---

Abstract -Unmanned aerial vehicles are also known as drones. These drones can play a crucial role at the time of any disaster, calamity, pandemic etc. The main aim of this paper is to present a scenario where drones are used for sanitizing public places such as hospitals, malls, railway stations, bazaars etc during the current COVID – 19 pandemic. There are many countries like China, South Korea, Honduras and Spain who have effectively used drones for spraying disinfectant in hotspot areas of COVID -19. Here, in India too, we have used the drones to sanitize many cities and hotspot areas which have subsequently brought down the number of newly infected cases of COVID -19. In this paper we have compared the COVID – 19 cases in Indian cities that have been sanitized using drones and that have not used drones for sanitization. Further to this, we have also compared the countries around the world who have resorted to sanitization using drones. The comparative study clearly shows that usage of drones for spraying disinfectant and thereby sanitizing the complete area has contained the COVID -19 pandemic to a larger extent.

Key Words:Unmanned aerial vehicle, Drone, sanitization, pandemic, COVID -19, hotspot.

1. INTRODUCTION

Aerial transport is widely used in applications such as military and civil emergency medicine[1], disaster management, rescue operations, material supply etc., owing to the speed of action, lack of restrictions and the ability to reach distant, otherwise inaccessible places. However, apart from the said undoubted benefits, air transport [2] also has limitations, which include dependence on weather conditions, relatively lower load capacity compared with ground ambulances, and much higher costs than in the case of land transport. Unmanned aerial vehicles, commonly known as drones, may be an alternative. The 20th century saw the development of unmanned aerial vehicles [4] controlled by radio waves, but it was the turn of the 20th and 21st centuries that resulted in an increased interest in their application for military purposes, mainly as an element of object recognition or antimissile exercises. Work on unmanned aircrafts or drones for aerial disaster management such as sanitization and direct transport has started recently [5].

2. COVID – 19

On December 31, 2019, hospitals in Wuhan, Hubei province, China reported on a cluster of cases suffering from pneumonia of unknown cause, attracting global attention. Two weeks later, a new variant of coronavirus was identified, which was named 'severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). SARS-CoV-2 is part of a group of viruses in a format similar to the crown (Corona), more specifically belonging to the species Betacoronavirus, such as the Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV). Over the next few weeks, it spread to18 countries (excluding China), and on January 30, 2020, the World Health Organization (WHO) declared the outbreak to be a Public Health Emergency of International Concern (PHEIC). Subsequently, on March 11th, it was declared a pandemic as it had spread to 113 countries[3].As of March 31, 2020, baring a few, almost all countries and more than a million people are affected. In terms of fatality, though the case fatality rate of SARS-CoV-2 is 3.44%, lower than MERS-CoV (34.4%) and SARS-CoV (9.19%), the absolute numbers affected are more.

SARS outbreak took place in 2002 in China and infected 8,422 people globally. The total number of deaths was 916 globally. As of March 31, 2020, the SARS-CoV-2 has infected over a million and has caused more than 50,000 deaths. One reason why its spread is evidently much wider as compared to SARS is the rapid urbanization and the increase in international travel during the last two decades. Hence, the control measures applied at the time of SARS are no longer adequate in these days, and more vigorous actions are required to control SARS-CoV-2. Another reason is related to a difference in the infectious period between patients infected with SARS and those infected with SARS-CoV-2. While in the former case, viral shedding peaks only when the patient's illness is advanced and respiratory symptoms occur, for SARS-CoV-2, transmission can occur in the early phase of the illness, when the patients are completely asymptomatic. Hence, isolation after the onset of symptoms might be ineffective in preventing virus transmission and this also makes temperature screening less effective. Finally, SARS-CoV-2 has been proven to hold higher transmissibility and wider

community spread than other betacorona virus.[5] Despite being highly infectious and having higher transmissibility, the severity of SARS-CoV-2 is much lesser compared to SARS.

COVID – 19 in India:

India's COVID-19 count inched close to the 50,000-mark as the states registered 2,958 fresh coronavirus cases in last 24 hours. The deadly novel coronavirus infected 49,391 in India. The death toll from the virus zoomed to 126 on Tuesday, May 5th . Maharashtra reported the highest number of COVID-19 death on Tuesday, taking total number of deaths in the country to 1,694.

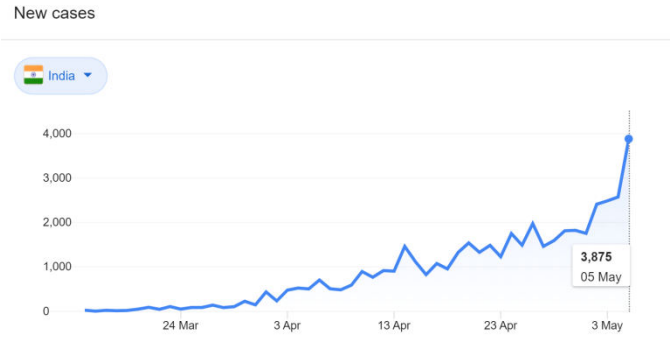

Figure 1: Corona cases in India as on 5.5.20

How the virus spreads:

Person to person contact:

Statistical models on the spread of SARS-CoV-2 suggested that, due to lack of herd immunity in the population and the highly contagious nature of the virus, 40-70% of the population can be infected unless strong containment measures are timely taken[7 9]. Based on the past experience with different epidemics and pandemics, as well as the current understanding of SARS-CoV-2, the WHO suggested frequent hand washing with an alcohol-based hand rub or soap and water, avoiding touching eyes, nose, and mouth, and practicing respiratory hygiene [3]. The use of face masks by everyone is still controversial, though WHO does not recommend its use by everyone.

Surface contact:

Coronavirus can survive on different surfaces for a long time – plastic (72 hours), stainless steel (48 hours), cardboard (24 hours), and copper (4 hours). As regard to contact spreading, the virus can be effectively inactivated by surface disinfection with 70% isopropyl alcohol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite. Hence, thorough cleaning with disinfecting solutions in health facilities and public places is warranted. Health care facilities are advised to use personal protective equipment (PPE) with triple-layered masks or N95 masks and to educate the staff about the proper disposal of the equipment. Respiratory precautions during aerosol-generating procedures are also recommended. Anyone with fever, cough, and difficulty in breathing is advised to seek medical attention. Social distancing (minimum one meter) is recommended both at individual and community levels.

At the community level, the most important measures for reducing infection spread rely on case detection, isolation, and contact tracing of positive cases, followed by quarantine for those exposed. Other strategies include the closure of places of mass gathering, like schools, libraries, places of worship, malls, and cinemas, and the suspension of all social events, as sports, celebrations, and meetings. Temperature screening has been introduced at airports, railway stations, and bus stations, as well as the entrance of the main community buildings (like hospitals, banks, or law courts). The limitation of temperature screening is that it misses a significant number of asymptomatic carries, which has been estimated at around 46%. In countries with a worse rate of infection, more restrictive measures have been put in place, like travel bans, reduction or interruption of both internal and overseas flights, and boundary closure; curfew and lockdown are also implemented.
All the aforementioned measures aim at reducing the rate of infection transmission, thus delaying the timing and lowering the height of the epidemic peak. These allow, from one side, gaining time for the healthcare system to prepare an efficient response to the pandemic, and, from the other side, the development of potential new treatments and vaccines. In Wuhan, it has been calculated that physical distancing with a staggered return to work at the beginning of April instead of March was the most effective strategy, with a projected reduction of the median number of infections by 92% (interquartile range (IQR) 66-97) and 24% (IQR 13-90) in mid-2020 and end-2020, respectively.

Need for Sanitization:

Coronavirus Disease 2019 (COVID -19) is an acute respiratory disease caused by a novel Coronavirus (SARS-CoV-2), transmitted in most instances through respiratory droplets, direct contact with cases and also through contaminated surfaces/objects. Though the virus survives on environmental surfaces for varied period of time, it gets easily inactivated by chemical disinfectants. Cleaning and sterilization are the essentials that need to be followed amid the COVID spread. Depending upon the number of users, disinfectants must be used frequently. India, being a country with huge population, the hygiene level is very low and care has to be taken to sanitize all essential things and areas. The most common and effective disinfectant is Sodium Hypochlorite (commonly known as Household Bleach) is available with 5-6 per cent solution which can be diluted with water.

Sanitization methods:
The guidelines are given below are focused on household settings and are meant for the general public.

- **Cleaning** refers to the removal of germs, dirt, and impurities from surfaces. It does not kill

germs, but by removing them, it lowers their numbers and the risk of spreading infection.

- **Disinfecting** refers to using chemicals, for example, Environmental Protection Agency (EPA)-registered disinfectants, to kill germs on surfaces. This process does not necessarily clean dirty surfaces or remove germs, but by killing germs on a surface *after* cleaning, it can further lower the risk of spreading infection.

General Recommendations for Routine Cleaning and Disinfection of Households

- Community members can practice routine cleaning of frequently touched surfaces (for example: tables, doorknobs, light switches, handles, desks, toilets, faucets, sinks, and electronics with household cleaners) and EPA-registered disinfectants external icon that are appropriate for the surface, following label instructions. Labels contain instructions for safe and effective use of the cleaning product including precautions you should take when applying the product, such as wearing gloves and making sure you have good ventilation during use of the product.

3. DRONES FOR SANITIZATION:

According to the (Centre for Disease Control) CDC, the virus is mainly transmitted via respiratory droplets or by touching contaminated surfaces [9]. Because drones spray from a height and are designed to soak/saturate surfaces, they can potentially disinfect both. Although more testing will be needed to verify the efficacy of just how well surfaces and air are disinfected, the empirical evidence alone suggests they could be a powerful instrument in the fight against the spread of the virus, especially in larger spaces like public walkways, public arenas and stadiums, shopping centers, truck bays, loading docks, vehicles, hospitals, and so on.
Drones are being used in India to combat against COVID-19. Police personnel and authorities have been using drones in various parts of India. In Punjab, Kerala, Mumbai, drones are being used by police to monitor lockdown violators. Police is using drones in different residential localities amid the lockdown. In other parts of India, drones are used for sanitization purposes too. In Delhi, drones were recently used to sanitize a society under quarantine. Similarly in Andhra Pradesh, authorities used drones to disinfect an area.

Essentially, the ability to mobilize drones to sanitize and clean large spaces on a regular basis will ensure a new level of safety and sanitization that, if done manually, would take hours or even days and put people at further risk of coming in contact with diseases. Because drones can be automated to do these jobs at regular intervals, it becomes less a matter of manpower and more a matter of determining what the efficient frequency of sanitation should be[10]. This could be a game changer in a world that has just awoken to realize how vulnerable it is to contagion at a global scale.

Figure 2: Drones being deployed to sanitize cities

Figure 3: Drones sanitization

4. USAGE OF DRONES IN THE INDIAN SUBCONTINENT:

Most of the cities in India have resorted to using drones for sanitization. The efficacy of using the drones for sanitization is that large areas can be covered in a short time. The drone pilots are stationed far away so that contactless spraying is done. Spraying of the disinfectant is also done in high rise buildings which other cannot be done by the traditional method.

Case studies:

The following are the cities which used drones for sanitizing the hot spots and other areas:

To contain the spread of novel COVID-19 pandemic at the hotspot areas of smart cities by disinfecting the areas using Unmanned Aerial Vehicles – Drones.

1. Hospitals,

2. Quarantined areas,

3. Government buildings and,

4. Other hotspot areas whichever is found necessary.

Spraying of sanitizer through Drones is prioritized for Hot spots and Containment areas identified by the District Administration / Chief Medical Officer. This is followed by Isolation areas, Quarantined areas, Shelter Homes and other places where manual spraying is difficult. The areas where Drones are to be deployed is decided by a team of the smart city officials.

The Drone team first visits the area planned to be sanitized for the day and makes a quick visual survey of the terrain, buildings and surroundings and chalks out a flight path to be followed by the Drone.

Sanitization process:

1. The Drone is filled with the chemical solution consisting of 1% Sodium Hypochlorite, [NaOCl], the drones is then calibrated and set ready to fly.
2. Drones are then flown using a remote-control device by the experienced Drone Pilots in the planned flight path, simultaneously spraying the Sanitizer through its four Nozzles.
3. After every flight (lasting approximately 15 to 20 minutes) the Drones are called back for refilling the Chemical and replacing the battery pack. The Drones are then moved to the next location to resume the flying/spraying.
4. The flight path of the drones and the area covered are controlled and recorded in a hand held device with GIS maps on the backend which is plugged to the remote controller.
5. The vehicles used for Drone Operations are fitted with GPS and GSM based wireless cameras using which the entire movement of Drones and their operations are centrally monitored from the Kashi Integrated Command and Control Centre, now converted to COVID19 War Room.
6. The Sanitary Inspector and other Team members report to the nodal officer before and after drone operations are carried out at each designated location.

1. Varanasi – Uttar Pradesh

The following are the areas, where the sanitization process using drones has been carried out:

Table -1: Areas of Varanasi which were sanitized

A total of 753.48 acres was sanitized in the city of Varanasi. The following table shows the areas which have been demarcated as hotspots in Varanasi.

S.No	Location	Area coverage (Acres)
1	Madhanpura and its areas	53.22
2	Murugayyatolla and its areas	29.46
3	Pitarkunda and its areas	29.63
4	Dhanialpur and its areas	43.1
5	Shivpur and its areas (Hospital)	58.9
6	Shivpur garden areas	3.46
7	Parmanandpur and its areas	40.3
8	VikasbhavanKajori	71.5
9	Bhim Nagar park	73.1
10	Gangapur-registry office	58.1
11	Gangapur Market	5.61
12	Madhanpura – 2rd time	23.9
13	SapthSagarMandi	58
14	Patrakarpuram	64.5
15	Municipal Corporation	67.7
16	Police Line	73

Table -2: Varanasi hotspot areas

S.No	Hot Spots	S.No	Hotspots
1	Madhanpura	17	Gangapur and its nearby areas
2	Suthamapura	18	Ganpur market and its nearby areas
3	Chaiya	19	SapthSagarmandi (areas)
4	MurugayaTolla	20	Patrakarpuram and Bhojuveer (areas)
5	Barothia	21	JP Mehta Inter College (areas)
6	Ajiramjan	22	Divisional Commisoner office
7	Dharara	23	Varuna Garden and its nearby areas
8	Bajardia	24	Sikraul Shelter home (areas)
9	Galla	25	Badaganseh

10	Ahmedh Nagar	26	Bullnala, Sidhmatagali, Nakkas
11	Dhanialpur and its nearby areas	27	Nawpura
12	Shivpur and its nearby areas	28	Police line
13	Shivur – Swastik Garden (areas)	29	Din dayal Hospital
14	Parmanandpur and its nearby areas	30	Ambalikapuri Colony, Chandu chitter and Sigra
15	VikasBhavan	31	Nagar Nigam office, Ashutosh colony
16	Bhim Nagar and its nearby areas	32	DrSampurnad stadium (areas)


Figure 4: Spraying of disinfectant in Varanasi

2. Bhopal – Madhya Pradesh:

Table - 3: Major areas in Bhopal which were sanitized

S.NO	SANITIZED AREAS	SIZE IN ACRES
1.	Peer Gate	122.3
2.	Bhopal smart city Corp.Ltd Building	6.6

Table - 4 : Bhopal hotspot areas which were sanitized

S.NO	HOTSPOT AREAS
1	Professors Colony
2	Durga Nagar
3	Semra
4	Shyamala Hills
5	Aishbagh
6	Jahangirabad
7	Shivaji Nagar
8	Char Imli
9	Indira Colony

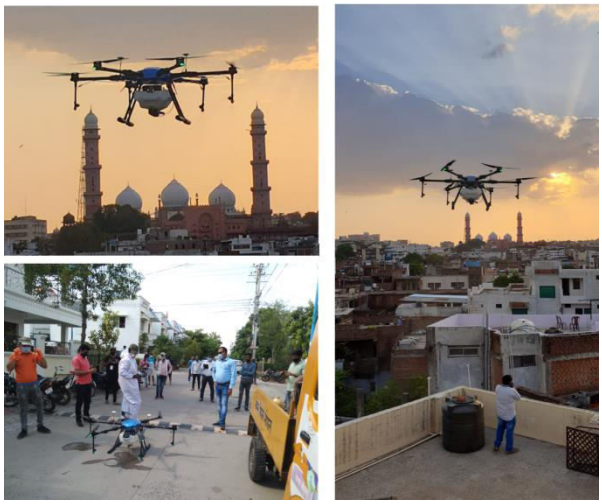

Figure 5: Sanitization work carried out in Bhopal

3. Chandigarh – Union Territory:

Sanitized areas:

Table - 5: Sanitized areas in Chandigarh

S.NO	SANITIZED AREAS	AREA IN ACRE
1.	Maloya Colony – A	01.23
2.	Maloya Colony – B	10.13
3.	SahibzadaAjit Singh Nagar	46.72
4.	Bair Majra	10.62
5.	Sector 45 – A	01.72
6.	Sector 45 – B	01.72
7.	MauliJagran	75.36
8.	Vikas Nagar	37.06
9.	Daria	37.06

10.	Buterla, Sector 41B	15.56
11.	Badheri Sector 41	42.25
12.	Sector 26 East	40.77
13.	Dhanas – A	22.23
14.	Dhanas – B	18.78

A total of 394 Acres were covered in the city of Chandigarh and the table below shows the hotspot areas where COVID cases are high.

Table - 6: Hotspot areas in Chandigarh

S.NO	HOTSPOT AREAS
1	Maloya Colony
2	Dhanas
3	SahibzadaAjit Singh Nagar
4	Bair Majra
5	Sector 45 – A
6	Sector 45 – B
7	MauliJagran
8	Vikas Nagar
9	Daria
10	Buterla, Sector 41B
11	Badheri, Sector 41
12	Sector 26 - BapuDham colony
13	Mohali
14	Panchkula

Figure 6: Drone sanitization in Chandigarh

4. Raipur: Chhattisgarh

The following areas were sanitized in the city of Raipur in the month of April 2020 when the COVID – 19 cases started seeing a rise in its number all over the country.

Table - 7: Sanitized areas in Raipur, Chhattisgarh

S.NO	SANITIZED AREAS	AREA IN ACRE
1.	Mekahara Hospital	15.82
2.	Officers Colony	15.32
3.	Devendar Nagar	19.02
4.	Samta Colony – A	29.40
5.	Samta Colony – B	12.60

A total of 92.16 acres were covered for sanitization. The following table shows the hotspot areas in Raipur.

Table - 8: Hotspot areas in Raipur

S.NO	HOTSPOT AREAS
1	Samta Colony
2	Mekahara Hospital
3	Devendar Nagar
4	Choubey Colony
5	Gudhiyar
6	Ramnagar
7	Khursipar
8	Rajnandgaon

Figure 7: Sanitization using drones in Raipur

5. ADVANTAGES OF USING DRONES

1. The most crucial factor in using the drone is the distance it can cover in a day is 20 km & a human can cover only 4-5 km which means 300 drones can cover & disinfect 6000 km linear in a day.

2. Drone based solutions are meant to substitute human health workers sanitation activities and to ensure that they don't get affected. The drones will do the same job but will be able to cover a lot more distance. Every day starting from 6 am to 6 pm, A drone works 12 hours where as a human being can work only 6-8 hours while carrying the heavy load of the equipment.

3. Vehicles & Ground workers can do only ground floor spraying activities, Our Cities have a lot of apartments & high risers with multiple floors which can be accessed only if Drones are used. Drones can fly up to 150 meters which is more than 400 feet.

4. The drones used for sanitization can cover even the high rise buildings where human intervention is dangerous. Also while sanitizing areas which are around 300 to 400 m far off from the given area, the drone pilots can view the area being sanitized using cameras attached to the drones.

6. GARUDA AEROSPACE PRIVATE LTD (GAPL):

GAPL is combating Corona Virus spread by conducting drone based sanitization operations in 26 Cities with a fleet of 300 Drones & 500 Pilots.

- The Company is also using Drones fitted with Loudspeakers to help Tamil Nadu Police to make Public announcements to monitor Section 144.

- GAPL has recently been enlisted by the Tamil Nadu Government to spray disinfectants on public spaces, including hospitals, five-star hotels, markets, government offices and roads across the State for 30 days and have covered 7,500 acres in the last 7 days.

- GAPL is also working with Varanasi Smart City Limited, Raipur Smart City Limited and Chennai Smart City Limited as part of their smart city initiatives on sanitization.

7. RESULTS AND COMPARISON OF COVID – 19 CASES IN CITIES AND CITY AREAS BEING SANITIZED:

The Indian Government has demarcated the districts of each state as Red zone, Orange zone and the Green zone according to the number of COVID - 19 cases. The classification is as follows:

Table 9: Zone categorization based on number of Corona cases

S.No	Zone colour	Remarks
1.	Red	Highest number of COVID – 19 cases.
2.	Orange	No COVID – 19 cases reported for 14 days.
3.	Green	No COVID – 19 cases reported for 28 days.

The following tables show the number of corona virus cases as on 4.5.2020 in the cities which have been sanitized by Garuda Aerospace private Ltd, using special drones. Here we are comparing the different areas of one particular smart city and display the statistics of those areas in terms of fresh COVID – 19 cases.

1. Varanasi:

Table - 9: Effect of sanitization in Varanasi areas

S.No	Location	Zone before sanitization	Zone after sanitization
1	Madhanpura and its areas	Orange	Green
2	Murugayyatolla and its areas	Orange	Green
3	Pitarkunda and its areas	Orange	Green
4	Dhanialpur and its areas	Orange	Green
5	Shivpur and its areas (Hospital)	Orange	Green

6	Shivpur garden areas	Orange	Green
7	Parmanandpur and its areas	Orange	Green
8	VikasbhavanKajori	Orange	Green
9	Bhim Nagar park	Orange	Green
10	Gangapur-registry office	Orange	Green
11	Gangapur Market	Orange	Green
12	Madhanpura – 2rd time	Orange	Green
13	SapthSagarMandi	Orange	Green
14	Patrakarpuram	Orange	Green
15	Municipal Corporation	Orange	Green
16	Police Line	Orange	Green

In Varanasi, the total cases as on 4.5.2020 was 31 and only one person has died since April 3rd 2020. This result shows that sanitization using drones will effectively bring down the number of COVID – 19 cases.

2. Bhopal:

Table - 10: Effect of sanitization in Bhopal areas

S.NO	SANITIZED AREAS	Zone before sanitization	Zone after sanitization
1.	Peer Gate	Red	Orange
2.	Bhopal smart city Corp.Ltd Building	Red	Orange

In Bhopal only 277 cases have been recorded and only 10 deaths have been reported, All the 10 were Bhopal gas tragedy victims whose respiratory systems were very weak to withstand the Corona infection.

3. Chandigarh:

In Chandigarh, a total of 191 cases were reported and the fresh cases were reported from areas which were not sanitized such as BapuDham colony, Mohali and Pachkula. The table below shows the effectiveness of sanitization in Chandigarh:

Table - 11: Effectiveness of Drone sanitization in Chandigarh

S.NO	SANITIZED AREAS	Zone before sanitization	Zone after sanitization
1.	Maloya Colony – A	Orange	Orange
2.	Maloya Colony – B	Orange	Orange
3.	SahibzadaAjit Singh Nagar	Orange	Green
4.	Bair Majra	Orange	Orange
5.	Sector 45 – A	Orange	Green
6.	Sector 45 – B	Orange	Green
7.	MauliJagran	Red	Orange
8.	Vikas Nagar	Orange	Orange
9.	Daria	Orange	Green
10.	Buterla, Sector 41B	Orange	Green
11.	Badheri Sector 41	Orange	Green
12.	Sector 26 East	Red	Orange
13.	Dhanas – A	Orange	Green
14.	Dhanas – B	Orange	Green

4. Raipur:

In Raipur, as of 4.5.2020, there are only 10 active cases who are admitted in AIIMS. Out of the 59 already infected, 49 have recovered and sent home. There are no new cases, no deaths in Raipur.

Table - 12: Effectiveness of Drone sanitization in Raipur

S.NO	SANITIZED AREAS	Zone before sanitization	Zone after sanitization
1.	Mekahara Hospital	Orange	Green
2.	Officers Colony	Orange	Green
3.	Devendar Nagar	Orange	Green
4.	Samta Colony – A	Orange	Green
5.	Samta Colony – B	Orange	Green

8. CONCLUSION

In this paper we have compared the effectiveness of Drone sanitization in four smart cities. Here we have shown that in a particular city, the areas which have been sanitized using drones, has contained the spread of the new covid – 19 cases compared to other areas of the same city which were not sanitized. Also it has been shown that the areas which had more number of cases has now reduced because of this sanitization process. The comparison tables have clearly shown that the doubling of active COVID – 19 cases is greatly reduced in the areas which were sanitized using drones. Conclusive results from effective analysis clearly indicates that surface spread and indirect contraction of COVID – 19 virus has been curbed to a large degree in hot spot areas where drone based sanitization was carried out.

ACKNOWLEDGEMENT

The author wishes to thank Prof. T.S.Natarajan, IIT Tirupathy, Dr. Sultan Ismail, DST and the management of Agni College of technology for their full support in publishing this work.

REFERENCES

1. A. Claesson, L. Svensson, P. Nordberg et al., "Drones may be used to save lives in out of hospital cardiac arrest due to drowning," Resuscitation, vol. 114, pp. 152–156, 2017.

2. M. Balasingam, "Drones in medicine—the rise of the machines," International Journal of Clinical Practice, vol. 71, no. 9, Article ID e12989, 2017.

3. European Commission, Communication from the Commission to the European parliament and the Council. A New Era for Aviation,European Commission, Brussels,Belgium,2014.

4. P. Van de Voorde, S. Gautama, A. Momont, C. M. Ionescu, P. De Paepe, and N. Fraeyman, "The drone ambulance [AUAS]: golden bullet or just a blank?," Resuscitation, vol.116, pp. 46–48, 2017.

5. T. Amukele, P. M. Ness, A. A. Tobian, J. Boyd, and J. Street, "Drone transportation of blood products," Transfusion, vol. 57, no. 3, pp. 582–588, 2017.

6. D. Sachan, "The age of drones: what might it mean for health?,"TheLancet,vol.387,no.10030,pp.1803-1804,2016.

7. G. Van Berlaer, T. Staes, D. Danschutter et al., "Disaster preparedness and response improvement: comparison of the 4 Emergency Medicine International 2010 Haiti earthquake-related diagnoses with baseline medical data," European Journal of Emergency Medicine, vol. 24, no. 5, pp. 382–388, 2017.

8.M.Mulero-P´azm´any,S.Jenni-Eiermann,N.Strebel,T.Sattler, J. J. Negro, and Z. Tablado, "Unmanned aircraft systems as a new source of disturbance for wildlife: a systematic review," PLoS One, vol. 12, no. 6, Article ID e0178448, 2017.

9. J. B. Rosser Jr., B. C. Parker, and V. Vignesh, "Medical applications of drones for disaster relief: a review of the literature," Surgical Technology International, vol. 33, pp. 17–22, 2018.

10.J.Braun,S.D.Gertz,A.Fureretal.,"Thepromisingfutureof drones in prehospital medical care and its application to battlefield medicine," Journal of Trauma and Acute Care Surgery, vol. 87, no. 1S Suppl 1, pp. S28–S34, 2019.

11. European Parliament, Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on Common Rules in the Field of Civil Aviation and Establishing a European Union Aviation Safety Agency, and Amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and Repealing Regulations(EC)No552/2004and(EC)No216/ 2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91, European Parliament, Brussels, Belgium, 2018.

12. International Civil Aviation Organization, Unmanned Aircraft Systems (UAS), International Civil Aviation Organization, Montreal, Canada, 2011.

13. N. Smolyanskiy, A. Kamenev, J. Smith, and S. Birchfield, "Toward low-flying autonomous MAV trail navigation using deep neural networks for environmental awareness," in Proceedings of the 2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), IEEE, Vancouver, Canada, September 2017.

14. A. Loquercio, A. I. Maqueda, C. R. del-Blanco, and D. Scaramuzza, "Dronet: learning to fly by driving," IEEE Robotics and Automation Letters,vol.3,no.2,pp.1088–1095, 2018.

BIOGRAPHIES (Optional not mandatory)

Agnishwar Jayaprakash is a young researcher and is very enthusiastic in encouraging research among the younger generation. He has completed his Master's degree in Harvard University and is interested in aerospace engineering. He has started a company called "Garuda Aerospace", which deals with various types of drones being used for disaster management. He also has to his credit other start up companies run by the students of Agni College of technology.