# INTERNATIONAL JOURNAL FOR LEGAL RESEARCH AND ANALYSIS

Open Access, Refereed Journal Multi Disciplinary
Peer Reviewed

www.ijlra.com

ISSN: 2582-6433

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ISSN: 2582-6433

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ISSN: 2582-6433

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ISSN: 2582-6433

# SPACE DEBRIS, ENVIRONMENTAL CHALLENGES, AND MITIGATION POLICIES

AUTHORED BY - JAYA JENIFER.A
BA.LL.B (HONS)

## Abstract

In this research paper, I aim to discuss my point of view on the growing problem of space debris, its environmental challenges, and the need for strong mitigation policies to ensure the long–term sustainability of outer space. With the increasing number of satellites and space missions, Earth orbit is becoming crowded with inactive satellites, rocket fragments, and other debris, which pose serious risks to operational spacecraft and future exploration. I believe this issue is not only a technological challenge but also an environmental and legal concern that requires urgent global attention. In my opinion, the UNCOPUOS Debris Mitigation Guidelines, along with the ESA and NASA reports, are important steps toward international cooperation, but stronger laws and enforcement mechanisms are still needed. Just Like we protect our natural environment on Earth, we must also treat space as part of our global ecosystem. Concepts from environmental law, such as the polluter pays principle and precautionary approach, can be applied to outer space to ensure accountability and sustainability.

The Lessons from environmental law like the precautionary principle, polluter pays principle, and sustainable development can guide us to frame better space governance rules. I also feel that the commercialization of space by private companies adds new responsibilities for ethical and environmental practices. This paper emphasizes that the future of space exploration depends on how responsibly we act today. It is essential for all nations to work together under a clear legal and ethical framework to protect outer space as a share and sustainable environment for generations to come.

## 1. Introduction

In today time, space become very busy and full of so many objects flying around earth. Every country and even private company launching satellites, rockets, and some testing missiles also. Because of this too much of materials is left in space which now we calling it space debris. This is like waste in outer space, like how on earth we have pollution and garbage. Space debris

ISSN: 2582-6433

include broken satellites, rocket parts, old spacecraft and also some small pieces from explosion or collision in space.

Now the problem is very serious because all this debris can hit working satellites or International Space Station. It will damage communication, GPS, internet and even defence systems. The scientist warning that if we not stop making this debris, soon we can't use some orbits anymore because too much junk will be there. I think this is not only a science or technical problem, but also legal and environmental problem which need urgent attention.

Outer space should be safe and sustainable for future generation. But sadly, there is no strong law like we have for earth pollution. We have some guidelines like UNCOPUOS and some rule from NASA and ESA, but they are not compulsory for all. That's why I feel international cooperation and strong legal policy is must.

In my opinion, we can learn from environmental law and apply same idea to space. Like "polluter pays principle" or "precautionary principle". If we can protect our oceans and forests, then we also can protect our space environment. Because space is also part of our ecosystem where all human depends for technology and research.

## 2. The Problem of Space Debris

Space debris means the waste thing that are floating around in the orbit of earth after so many years of space activity. These are not working satellite, broken rocket parts, and also some screws, paint pieces, and even tiny metal particles. It looks small but move very fast, faster than bullet speed, so it can cause big damage if it hit any satellite. Now the number of this debris become very high, because every day new satellites are sending up but old ones not removed.

NASA report say there are lakhs of debris pieces bigger than 1 cm, and millions of smaller one. Some are from old missions of USA, Russia, India and many countries who doing experiments from 1960s itself[1]. Even one collision in space can make hundreds of new debris pieces. Example is the 2009 collision between Iridium and Cosmos satellite which create huge junk.
This debris is danger for working satellites which giving us GPS, mobile network, weather

[1] https://currentaffairs.adda247.com/nasa-released-the-data-on-indias-space-debris/

ISSN: 2582-6433

forecast, etc. Also, astronauts in International Space Station also in risk. One small piece can damage the wall of space station and risk life.

The problem becomes more complicated because nobody owns the outer space, so nobody takes full responsibility to clean. Some country doing research to remove debris by net or laser, but still only at testing level.

So, I feel this problem is not only scientific but also political and legal issue. If no international agreement come soon, we will make space a junkyard and it will be difficult to launch new missions safely.

## 3. Environmental Challenges of Space Debris

Many people thinking space is empty place, but actually it is not so. Just like our earth environment, outer space also part of human environment where many human activities happening now. The growing space debris is like pollution in space, and it can create many environmental dangers. We always talk about global warming, air and water pollution, but we forget the space pollution which is slowly increasing every year.

The first challenge is that debris don't go away easily. Some pieces stay in orbit for hundreds of years, especially in high orbit. So, the problem is permanent. When sunlight and gravity act on these debris, they sometimes come down and burn in atmosphere, but big pieces can reach the ground and make damage. This is like waste disposal problem but in sky.

Second, the debris can destroy new satellites, which means more launches are needed again and again. This increase carbon emission and fuel burning, so it also affects earth climate indirectly. Third, if one satellite crash with another, it produces more fragments and create what scientist call "Kessler Syndrome", where debris keep multiplying. That is like a chain reaction of pollution in space.

I believe that we must see space debris as environmental issue also, not only technical. Like how we protect forest or ocean, we must protect orbit region of Earth. But right now, no law or international system to monitor and punish space pollution strictly. Every nation act separately. If this continues, future generation will have dangerous sky instead of clean one.

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## 4. Legal and Policy Frameworks

When we see about space law, it is still very less developed compare to other law like environmental or human right law. The main law that talks about outer space is the Outer Space Treaty of 1967. It says space is for peaceful use and no country can claim ownership. But it not says clearly who is responsible for cleaning debris or how to control space pollution. That is big gap in the law.

Later on, United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) made some Space Debris Mitigation Guidelines. These guidelines give advice how to design, operate and remove satellites safely. But it is not compulsory, only voluntary. That mean if a country not follow, there is no punishment. So, in my opinion, these guidelines are good step but not strong enough to solve debris problem.

Also, ESA (European Space Agency) and NASA (National Aeronautics and Space Administration) also making policies for debris control like "25year rule" which mean after mission finish, satellite should be removed from orbit within 25 years. But again, this is not a strict law. India also follows some debris mitigation in ISRO (Indian Space Research Organisation) mission but we need more awareness and cooperation.

We can learn from environmental law also. For example, in pollution cases, the one who cause pollution must pay. This "polluter pays" principle can be used for space also. If any company or country leave junk in orbit, they should bear cost of removal. That will make people more responsible.

Without clear rule and enforcement, the debris will keep increase. I think world must come together to make one strong international agreement just like Paris Agreement for climate change, but this time for space environment.

## 5. Lessons from Environmental Law

I personally feel that environmental law can give us so many lessons to handle space debris problem. On earth, we have learned through many mistakes like pollution, deforestation and climate change. But we made some rules like "polluter pays", "precautionary principle" and "sustainable development". These same ideas can be used in space also.

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First, the **precautionary principle** means even if we don't have full scientific proof of damage, we must take precaution to avoid harm. In space also we should not wait until big accident happen. Countries should plan safely before launching and should remove old satellites before they break down. This principle can save future orbit from becoming dangerous.

Second is the **polluter pays principle**. If any country or private company make debris, they should pay money for cleaning or compensation. Right now, nobody paying anything. Everyone just keeps launching and forget about old junk. This is not fair because all human using same space environment. So, this law can make people more responsible and careful.

Third is **sustainable development**, which mean we should use resources without spoiling it for future. Space also resource for science and communication. So, our action today should not harm tomorrow's generation. If we learn from these laws, we can make better space governance rules.

In my opinion, if international body like United Nations combine environmental law idea with space policy, then we can get stronger system. Space law now is like small child; it needs to grow with help of environmental experience. That way, we can make sure space remain safe, clean, and useful for everyone.

## 6. Commercialization and Ethical Responsibilities

Nowadays space is not only used by government but also by private companies. Many big companies like SpaceX, Blue Origin, and even small startups are launching satellites for internet, navigation, and business[2]. This is what we call commercialization of space. It is good for development and technology, but it also brings new kind of responsibility. When more private companies go to space, more rockets are launching, and that means more debris risk also.

Private company main aim is profit, so sometimes they ignore environment side. But I feel they must also follow ethical and environmental rules like government. Space is not owned by any one country or company. It is shared by all humanity. So, everyone using it must be careful and respectful.

[2] https://spaceinsider.tech/2024/04/30/spacex-vs-blue-origin-a-detailed-comparison-in-2024/ -

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There is also question of accountability. If one private satellite break and cause damage to other, who will pay? The company or the country that registered it? There is still confusion in international law about this. That's why I think new policy must make both government and private sector responsible.

Ethics also play big role here. We should not treat space only as money making area. It is part of natural environment and we should explore it with moral responsibility. Like in environmental ethics, we say "respect nature", same thing we must apply in space.

Commercialization should go together with sustainability. Maybe every private company can contribute to global cleaning mission or pay small space environment tax. That way they become part of solution, not the problem. In my view, development is important but without responsibility it will create future disaster[3].

## 7. Towards Stronger Mitigation Policies

If we really want to solve the problem of space debris, we need more strong and clear mitigation policies. Only talking or making guidelines will not be enough. Many countries have made small rules for their own missions, but space is not belonged to one country alone, so only international level rule can work properly.

First, there should be a **global agreement** where all countries and even private companies follow same standard. Like how we have Paris Agreement for environment, we may have "Space Debris Control Agreement". This can include compulsory rule for debris removal, limitation of rocket stages, and recycling of satellites after mission end.

Second, I think we must use new technologies for debris cleaning. Some scientist trying with laser beams, nets, magnets, and robots to catch debris. But these are costly and no one want to pay for it. So, countries should make one **joint space fund** for cleaning activities. That way, no one escape from responsibility.

Third, there should be a monitoring system under United Nations or new global space authority which can keep record of all debris and punish those who not follow rules. If we make clear

[3] https://www.sciencedirect.com/science/article/abs/pii/S0160791X99000032 -

ISSN: 2582-6433

accountability, then countries will act seriously.

Also, we should encourage people and student awareness about space environment. Education is powerful for future generation to understand that space also part of our home.

In my opinion, mitigation policy should not be only about removal but also prevention. If we launch less, reuse more, and cooperate globally, we can keep outer space safe. If we delay, soon it will be too late to clean the mess we already made.

## 8. Conclusion

After studying about space debris and its impact, I really feel this is one of the biggest hidden dangers for future. Many people don't even know that so much waste is floating above our head. But slowly it is becoming big environmental and legal issue. Space debris can destroy satellites, disturb scientific mission and also increase pollution in our sky.

We humans always make progress but forget to clean what we leave behind. Same thing is happening in space. Like we polluted land, water and air, now we are polluting orbit. So, we must learn lesson from past. It is time to act before situation go out of hand.

In my opinion, both government and private companies must share responsibility. There must be strong international cooperation and new legal framework to control debris. Space should not be treated like dumping ground. If we can make laws for pollution control on earth, we can also make for space.

The ideas from environmental law like precautionary principle, polluter pays and sustainable development can give very good base for making space policy. Also ethical duty is important because space belong to all humanity, not to rich countries only.

I strongly believe that the future of space exploration depends on how we act today. If we protect our orbits, then our coming generation can use space safely for research, communication and peace. If we ignore, then we will lose it forever. So, we must treat space as part of our global environment and take care of it with same respect as we give to our nature on Earth.

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