

A Comprehensive Study on the Impact of Dumping of Non Biodegradable Material in Water Bodies in Tamil Nadu

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ABSTRACT

This study investigates the intricate ecological, cultural, and environmental dimensions of Ganesh Chaturthi, focusing on the transition from eco-friendly clay idols to chemically processed Plaster of Paris (PoP) idols. Originally a festival grounded in sustainable traditions, Ganesh Chaturthi has evolved in ways that have introduced serious environmental challenges. By contrasting historical eco-conscious rituals with present-day practices, the research illustrates how the use of natural clay once supported soil health and respected natural water systems, while modern alternatives now contribute to marine pollution and deteriorating water quality. The paper explores the cultural heritage of clay idol-making, its spiritual significance, and regional customs in states like Tamil Nadu and Maharashtra, revealing how idol immersion was traditionally linked with practices like rainwater harvesting and groundwater recharge. Drawing on traditional ecological knowledge (TEK), community-based rituals, and the role of artisans, the study underscores the synergy between spirituality and sustainable water management in earlier times. In contrast, contemporary use of PoP, synthetic dyes, glitters, and industrial paints has disrupted ecological balance, harming aquatic biodiversity and threatening the livelihoods of traditional craftsmen. The research also reviews scientific findings on water quality post-immersion, regional examples, and environmental initiatives by NGOs and authorities. Ultimately, the study calls for a revival of eco-conscious idol-making and offers practical strategies to align environmental sustainability with religious observance. It concludes by encouraging policymakers, educators, and cultural leaders to protect the ecological essence of Ganesh Chaturthi through advocacy, regulation, and the restoration of time-honored practices.

Keywords: Eco friendly PoP, synthetic dyes,

INTRODUCTION

Vinayagar Chaturthi, also known as Ganesh Chaturthi, is a prominent Hindu festival honoring Lord Ganesha, revered as the deity of wisdom and remover of obstacles. It is predominantly celebrated across Indian states such as Maharashtra, Tamil Nadu, Karnataka, and Andhra Pradesh. The festivities generally last for ten days and involve placing idols of Lord Ganesha in households and public spaces. Devotees

perform rituals that include offering sweets—particularly modaks—along with flowers, music, dancing, and community gatherings. The festival has roots that are both spiritual and socio-political. In the late 1800s, Indian freedom fighter Bal Gangadhar Tilak popularized Ganesh Chaturthi in Maharashtra as a large-scale public celebration to foster unity among Indians during colonial rule. Over time, this transformed the event into a unique combination of faith, cultural expression, and social consciousness. Historically, however, the festival was practiced in a more environmentally conscious manner, utilizing natural clay and organic colors for idol-making.

Spiritually, the festival emphasizes Lord Ganesha's association with beginnings and obstacle removal. According to myth, he was created from clay by Goddess Parvati and later immersed in water—a ritual that symbolized a respectful return to nature. Traditionally, this cycle was honored using eco-friendly materials that reinforced a balanced relationship between people and the environment. In recent years, however, commercial influences have led to the widespread use of Plaster of Paris (PoP) idols, synthetic dyes, and plastic-based decorations. While these options are cheaper and more visually impressive, they have harmful effects on the environment, contributing to water contamination and endangering aquatic ecosystems. Additionally, such practices stray from the festival's original environmental harmony. This study emphasizes the importance of embracing sustainable traditions to maintain both spiritual values and ecological balance.

Hypothesis: This research posits that promoting and reinstating the use of traditional clay idols during Ganesh Chaturthi significantly enhances environmental sustainability by protecting water resources and reducing harm to aquatic life, in contrast to the continued use of PoP idols. It also suggests that strong policy implementation and grassroots-level environmental campaigns can help bridge the divide between religious observance and ecological responsibility, eventually making green celebrations the standard. The goal is to examine whether these traditional, sustainable practices can serve as effective models for other environmentally friendly festivals and foster greater community participation in ecological conservation.

Review of literature

The crafting of clay idols is a time-honored tradition that embodies the artistic excellence, spiritual depth, and ecological awareness rooted in Indian heritage. Historically, this craft was practiced by skilled potters who regarded idol-making as a sacred duty. The clay, often collected from temple tanks or sacred rivers, was treated as holy. The process involved no machinery—each idol was shaped entirely by hand, reflecting values of devotion, simplicity, and humility. Symbolically, clay represented the transient nature of life, echoing the belief that “what is created must eventually return to the earth.” On a practical level, clay idols dissolved naturally in water without leaving pollutants, thus preserving aquatic life. The colors used were derived from nature—turmeric for yellow, indigo for blue, and vermilion for red—while decorations were simple, often incorporating natural items like flowers, coconut shells, and banana leaves.

These traditional idols also played a key role in fostering community connections. Potters typically received orders well in advance, with families visiting personally to customize their idols, making the experience deeply personal and communal. Events like idol-making workshops, installations, and processions brought people together, aligning spiritual rituals with seasonal changes and reinforcing a harmonious connection with nature and farming cycles. However, the shift toward Plaster of Paris and chemical-based paints has negatively impacted both the environment and the livelihoods of these artisan communities. This modern transition has not only polluted water bodies but also eroded cultural richness

and disrupted sustainable local economies. Restoring the practice of using clay idols offers an environmentally conscious alternative and helps safeguard India's valuable artistic and cultural traditions. ECO-SPIRITUAL PRACTICES IN ANCIENT INDIA In ancient India, spirituality and environmental stewardship were deeply interconnected. The idea of *Dharma* extended beyond human ethics to encompass care for all elements of nature—including animals, forests, rivers, and the air. Religious rituals and cultural festivals were designed in a way that naturally promoted ecological preservation. Celebrations such as Ganesh Chaturthi were not merely acts of devotion but expressions of gratitude toward nature, aligning human life with natural rhythms and environmental cycles.

During Chaturthi, idols were crafted from sacred clay, often collected respectfully from the earth through rituals that acknowledged the act and sought nature's forgiveness. Immersion, or *visarjan*, symbolized a sacred cycle of dissolution and regeneration, rather than just discarding the idol. Harmful materials were avoided, as polluting nature was believed to result in spiritual and karmic consequences. Water bodies like temple tanks, wells, and village ponds served not only as religious gathering spots but also as systems for local water management. Festivals were purposefully timed to coincide with the agricultural cycle and post-monsoon season, ensuring that immersions took place in replenished water sources without harming ecosystems.

Natural elements like banana leaves, flowers, and plant-based fibers were used for decoration, leaving no synthetic waste behind. Folk songs, myths, and stories about Lord Ganesha often emphasized respect for animals, forests, and the earth. These practices reflect a worldview in which ecological balance and spiritual practice were inseparable. Today, these ancient eco-spiritual values offer vital lessons for reimagining modern celebrations in a more sustainable and environmentally respectful way.

NATURAL RESOURCES AND TRADITIONAL CRAFTS Traditional idol-making in India was deeply rooted in ecological balance and sustainable resource use.

Artisans sourced clay—called “shadu mati” in Maharashtra and “mann” in Tamil Nadu—from local riverbanks, lakebeds, and temple tanks, often with ritualistic reverence that encouraged conservation. These eco-friendly practices extended to the use of natural materials such as dried husk, coconut coir, cow dung, rice flour, banana stems, betel leaves, and turmeric for crafting and decorating idols. Tools were typically handcrafted from bamboo or wood, ensuring a low environmental footprint. These crafts were localized, community-driven, and played a vital role in supporting rural livelihoods, particularly among the potter communities (kuyavar/kumbhar), whose skills were central to cultural and spiritual life. Festivals like Ganesh Chaturthi provided seasonal income and reinforced their importance in society. However, the shift to chemically-produced Plaster of Paris (PoP) idols has harmed both the environment and artisan communities. Promoting traditional idol-making practices today is not only a step toward ecological sustainability but also a way to restore rural employment and preserve cultural heritage.

MUD IDOLS AND MOISTURE RETENTION IN SOIL

A lesser-known yet ecologically impactful benefit of traditional clay idol immersion is its role in enhancing soil moisture and conserving water in local ecosystems. When these mud idols are dissolved in natural water bodies such as ponds, tanks, or lakes, the clay settles at the bottom, forming a thin layer that reduces water evaporation and helps maintain water levels well into the dry season. In regions like Sivaganga and Ramanathapuram in Tamil Nadu, this process was intentionally utilized to improve water retention, supporting the growth of algae that sustained aquatic life. The practice served both religious and ecological purposes, with farmers regarding it as a sacred contribution to the upcoming agricultural season.

Additionally, the natural minerals in the clay, including iron and magnesium, enriched the aquatic environment, attracting beneficial microbes and silt-tolerant species that increased the fertility of the water body. This synergy between spiritual rituals and environmental sustainability illustrates the wisdom of traditional practices. In contrast, modern Plaster of Paris (PoP) idols with synthetic paints disrupt this balance, leaving behind insoluble residues that clog the soil, reduce tank porosity, and harm ecosystems. Returning to clay idols not only respects cultural traditions but also offers a natural, sustainable method to conserve water and nurture biodiversity.

RIVER CONSERVATION THROUGH CLAY IDOL IMMERSION

Historically, immersing clay idols in rivers and ponds was not only a spiritual act but also a method of water conservation. Made from natural, biodegradable materials, these idols dissolved harmlessly in water, posing no threat to aquatic life. The ritual symbolized the divine's return to nature and fostered a deep respect for water bodies. In many communities, immersion was paired with the cleaning of rivers and ponds, encouraging stewardship and environmental care. In regions like the Cauvery delta in Tamil Nadu and the Godavari basin in Maharashtra, immersions were done in designated tanks or shallow river areas to preserve the main water flow and promote community interaction with nature. Traditional stepwells or "kulams" were often used for idol immersion, helping filter sediment and recharge groundwater. These practices maintained ecological balance and were sometimes followed by tree planting, turning religious events into environmental efforts. In contrast, modern Plaster of Paris (PoP) idols and chemical-based paints release harmful substances into water bodies, leading to toxicity, aquatic deaths, and blocked drainage systems. The original eco-conscious intent of these rituals has been overshadowed by commercialization.

Reviving the use of clay idols and regulated immersion spaces is vital to restoring their sacred role in river conservation.

THE SHIFT TO PLASTER OF PARIS IDOLS

The shift from traditional clay to Plaster of Paris (PoP) idols began in the mid-20th century as urban populations grew and the demand for more elaborate and larger idols increased. PoP, a quick setting material made from gypsum, allowed artisans and manufacturers to mass-produce idols with less time and labor compared to the slow, hand-crafted clay process. As a result, markets quickly adopted PoP for its ease of molding and cost-effectiveness.

However, this transition came at a significant environmental cost. Unlike natural clay, PoP is not biodegradable and does not dissolve easily in water. When immersed in rivers, lakes, or seas, these idols often remain intact for weeks or even months, leaching harmful substances into the water. Moreover, removing residual PoP from water bodies is both difficult and expensive, requiring mechanical dredging that disturbs aquatic ecosystems.

The rise of PoP idols also triggered a decline in demand for traditional potters and artisans, leading to unemployment and the erosion of generational crafts. Many potters were forced to switch to using PoP just to stay competitive, further exacerbating the problem. In addition, PoP idols are frequently painted with bright synthetic colors containing lead, mercury, and cadmium, all of which are toxic when released into water.

The use of PoP may have offered economic advantages in the short term, but its long-term consequences include water pollution, loss of biodiversity, and the destruction of cultural craftsmanship. The challenge

now lies in reversing this trend through awareness, regulation, and support for sustainable alternatives that retain both cultural and ecological integration.

CHEMICAL PAINTS: ORIGINS AND RISE IN USE

Alongside the rise of Plaster of Paris idols came the widespread use of chemical paints. These paintings, often chosen for their vibrant colors and glossy finishes, became popular in the late 20th century as demand for visually striking idols grew. Unlike natural pigments derived from turmeric, indigo, or sandalwood, chemical paints contain synthetic dyes and heavy metals that pose significant health and environmental risks.

The most concerning components of these paintings include lead, cadmium, mercury, chromium, and arsenic. When idols painted with such chemicals are immersed in water bodies, these toxic elements leach into the water, contaminating both surface water and groundwater. The impact is immediate and visible ingredients: dead fish, algae blooms, foul Odors, and sedimentation of bright-colored sludge on the riverbed.

Artisans often lack knowledge or access to safe alternatives and are driven by market demands for "flashy" idols. The more vivid and metallic the finish, the more likely an idol is to attract buyers. This commercial pressure contributes to continued use of harmful substances despite their known toxicity.

Even small idols made for home worship are not exempt from these dangers. Immersing chemically painted idols in household water tanks, wells, or even bathtubs lead to toxic residue being released into the drainage system, eventually reaching municipal water sources.

Addressing this issue requires a two-pronged approach: enforcing regulations that ban harmful pigments and simultaneously promoting the production and availability of safe, natural colors. Only then can we break the cycle of demand-driven toxicity and restore the purity of both waters.

IMPACT OF GROUNDWATER QUALITY

The immersion of PoP idols and chemically painted decorations significantly affects groundwater quality in urban and rural areas alike. When these idols are immersed in local ponds, tanks, rivers, or even artificial water bodies, toxic substances leach into the soil and slowly percolate into the groundwater. Since groundwater is a primary source of drinking water and irrigation in India, this contamination poses a major public health concern.

Heavy metals such as lead, cadmium, and mercury are commonly detected in post-immersion water samples. These metals do not biodegrade and can persist in soil and aquifers for years. When they enter the human body through drinking water or crops grown using contaminated irrigation, they may cause neurological damage, kidney dysfunction, developmental disorders, and even cancer. In a study conducted by the Central Pollution Control Board (CPCB), water samples from lakes in Hyderabad, Mumbai, and Chennai showed a substantial increase in heavy metal content and pH imbalance following idol immersion. Aquatic flora was affected, and microbial activity in the soil declined due to chemical interference.

Moreover, the PoP itself forms a thick slurry on the bed of water bodies, clogging pores in the soil and reducing its ability to recharge aquifers. This weakens the natural water filtration capacity of the earth, which is essential for replenishing clean groundwater. As a result, even areas that traditionally enjoy clean water sources now face challenges in maintaining water quality.

Solutions must include regulated immersion zones with safe materials, soil remediation programs, and

awareness drives to discourage toxic materials at the source. A renewed commitment to eco-traditions is the first step toward protecting our underground lifeline.

IMMERSION EFFECTS ON MARINE LIFE

Marine life is among the most severely affected by the mass immersion of PoP idols and other non-biodegradable offerings during Ganesh Chaturthi. Coastal cities like Mumbai, Chennai, and Visakhapatnam report significant ecological disruption in the days following visarjan (immersion). Fish deaths, coral bleaching, and plastic ingestion are common outcomes of pollution caused during this time.

When idols made from PoP are immersed in oceans or estuaries, they do not disintegrate but break into fragments, clogging feeding, and breeding zones for aquatic organisms. The presence of synthetic paints and metallic glitters adds a chemical load to the already burdened marine ecosystem. These substances alter the pH level of seawater and introduce toxins that affect the gills, livers, and reproductive systems of fish and crustaceans.

Moreover, materials such as thermacol (polystyrene) used in decoration are mistaken for food by marine species like turtles and seagulls, leading to internal blockages and starvation. In coral zones, sediments from immersion activities can coat coral reefs, block sunlight and prevent photosynthesis, which is critical for their survival.

The ripple effect extends to human communities that depend on fishing for livelihood. Decline in fish populations and toxicity in seafood impacts nutrition, economy, and biodiversity. In some coastal areas, authorities have banned immersion in open seas and instead built artificial tanks for eco-friendly visarjan, but enforcement remains a challenge.

A combination of eco-sensitive policies, community awareness, and a shift back to clay idols can prevent further marine degradation. Protecting the oceans begins with restoring the purity of our religious observances.

TOXICITY IN FRESH WATER ECOSYSTEMS

Freshwater ecosystems such as lakes, rivers, and ponds are fragile environments that are easily destabilized by pollutants. Idol immersion, when done using synthetic materials, introduces a host of contaminants that affect water chemistry, biodiversity, and aquatic food chains. These impacts are magnified in cities with high population density and limited water maintenance.

Toxic paints, glitter, plastic accessories, and thermocol bases release a cocktail of chemicals into the water. These increase chemical oxygen demand (COD) and biological oxygen demand (BOD), leading to oxygen depletion—a major cause of fish kills. Water becomes cloudy and acidic, disrupting photosynthesis in aquatic plants and reducing the population of phytoplankton, the base of the aquatic food web.

Even organic materials like flowers and milk, when dumped in excess, lead to eutrophication—an overgrowth of algae that blocks sunlight and eventually depletes oxygen. This chain reaction results in dead zones where aquatic life cannot survive. Microbes that digest these substances also increase, but some may become pathogenic, posing risks to humans who use water for bathing or washing.

The immobile PoP residues settle on the lakebed and create a cement-like layer that suffocates bottom-dwelling species and prevents natural sediment turnover. Once such damage occurs, recovery is slow and costly, often requiring full-scale dredging and artificial restoration.

Traditional clay idols, on the other hand, blend seamlessly with the waterbed, enriching it without upsetting its balance. Promoting eco immersionpracticesandeducatingcommunitiesatproperdisposalcan helpprotectthehealthof our freshwaterecosystemsfor generationsto come.

GUIDELINESANDGAPS

Recognizing the environmental damage caused by idol immersion, the Indian government has issued multiple guidelines throughagenciesliketheCentralPollutionControlBoard(CPCB)and various statepollutionboards. These guidelines recommendtheuseof natural clay, water-soluble paints, and designated immersion zones with artificial tanks to prevent contamination of natural water bodies.

Theguidelinesalsobantheuseoftoxicpaints,thermocolor,andplastics during festival decorations. However, implementation remains inconsistent. In many cities, lack of monitoring, political interference, andpublicnon-compliancehaverenderedtheserulesineffective. Local authorities often grant last-minute permissions for large-scale idol processions that violate environmental norms.

Additionally, awareness about these guidelines is low among both artisansandthepublic. Manyidolsellersarenotrainedineco-friendly practices,andtherearenocertificationsystemsforidentifyingeco-safe idols. Without regulation at the production level, harmful idols continue to flood the market.

Some progressive cities like Pune and Bengaluru have introduced stricter controls and launched awareness drives with reasonable success. Yet, nationwide implementation is needed. Moreover, religious sentiments and cultural beliefs must be considered in policymaking—education and community involvement are more effective than bans alone.

A comprehensive approach that combines regulation, education, and incentivescanbridgethesegaps. Governmentbodiesmust collaborate with artisans, NGOs, and citizens to ensure the festival becomes a model of sustainable celebration.

METHODOLOGY

Data is collected and analysed by survey method, Case study is also included in the area of study

DATA RESULT

CASE STUDY: CHENNAI COASTAL IMPACT

Survey Results Table: Eco-Friendly Ganesh Chaturthi Practices	
Question	Response (%)
Use of Clay Idols (%)	65
Use of PoP Idols (%)	35
Aware of Environmental Impact (%)	80
Participate in Eco Campaign (%)	45
Avoid Chemical Paints (%)	50
Support Policies (%)	70
Prefer Eco Materials (%)	75
Willing to Pay More (%)	55
Observed Water Changes (%)	40
Learning Source - Schools (%)	35
Learning Source - NGOs (%)	25
Learning Source - Social Media (%)	40

, Chennai, with its extensive coastline, faces unique challenges during Ganesh Chaturthi. Thousands of idols are immersed in the Bay of Bengal at Marina Beach and Besant Nagar, leaving behind mounds of debris—PoP fragments, thermocol, plastic garlands, and synthetic cloth. These pollutants not only degrade the coastal ecosystem but also impact on marine life and local fishing communities. The Tamil Nadu Pollution Control Board has repeatedly issued advisories against beach immersions. Despite this, public adherence has been limited. Cleanup operations by the Chennai Corporation and NGOs like Urbaser Sumeet and The Nature Volunteers collect tons of waste annually post festival. Fishermen often report reduced fish catch and damaged nets due to idol remains on the sea floor.

Some positive interventions include the installation of artificial immersion tanks in Besant Nagar and awareness drives among school children. Yet, without strict enforcement and a shift in public mindset, Chennai's coastlines remain vulnerable. Sustainable immersion practices, education, and policy reforms are urgently needed to protect the city's marine biodiversity and preserve its natural heritage.

IMPACT OF PLASTER OF PARIS (POP) IDOL IMMERSION ON SULPHATE LEVELS IN WATER BODIES ACROSS INDIAN STATES DURING AND AFTER VINAYAGAR CHATURTHI

TAMILNADU

Time period	Approx. Sulphate (mg/L)
Before PoP immersion	50 – 70
Immediately after immersion	150–200
After 1 month (post- monsoon start)	~120–140
After 2 months	~90–110

After 3 months (end of rainy season)	~75–90
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DISCUSSION

Growing awareness around the environmental consequences of idol immersion has led to an increasing preference for traditional clay idols, with 65% of respondents favoring them due to cultural and ecological reasons, and 80% showing awareness of the harmful effects of Plaster of Paris (POP) idols. Despite this awareness, the adoption of sustainable practices remains limited, as only 45% actively participate in eco-friendly immersion campaigns and just 50% avoid chemical paints and glitter. Notably, 70% of people support stricter government regulations to enforce eco-conscious practices, and 75% believe that eco-friendly materials are the ideal choice for idol-making, with over half willing to pay more for such alternatives. Scientific studies reinforce this urgency for change, as environmental monitoring during and after Ganesh Chaturthi has shown alarming spikes in pollutants such as BOD, COD, heavy metals, and turbidity in water bodies like the Mula-Mutha River in Maharashtra and Hyderabad's Hussain Sagar Lake. These pollutants not only degrade water quality but also pose severe threats to aquatic ecosystems, human health, and agriculture by contaminating soil and groundwater. Research by CPCB, NEERI, and other institutes highlights that many lakes take several months to recover even with cleanup efforts, and immersion-related waste leads to eutrophication and aquatic life loss. With long-term degradation being a real and persistent risk, scientific recommendations now advocate for biodegradable idols, artificial immersion tanks, and improved community-based water monitoring. These findings, backed by both data and public opinion, underscore the urgent need to shift from traditional POP idols to sustainable practices that protect both cultural traditions and environmental health (Sources: CPCB, NEERI, The Hindu).

CONCLUSION

Non-Biodegradable Nature of POP Evidence: POP is made from calcium sulfate hemihydrate. Once it sets (after mixing with water), it becomes calcium sulphate dihydrate, a hard substance that does not dissolve easily in water or break down naturally. Impact: It accumulates on beaches and sea floors, causing long-term pollution. Source: Central Pollution Control Board (CPCB), India

Blocks Natural Water Flow and Aquatic Life Evidence: POP idols or waste left in water bodies clog estuaries, creeks, and mangrove channels. Impact: Affects the tidal flow, traps sediments, and disrupts fish breeding grounds. Study: A 2017 report by National Environmental Engineering Research Institute (NEERI) confirmed POP deposition in Mumbai's coastal waters after idol immersions.

Release of Toxic Chemicals and Paints Evidence: POP idols are often painted with lead-based or toxic paints (e.g., mercury, cadmium). Impact: These chemicals leach into coastal waters, harming plankton, fish, and even birds. Example: A study by The Energy and Resources Institute (TERI) found heavy metals in water samples post-Ganesh Chaturthi immersion in coastal areas like Mumbai and Chennai.

Smothering of Marine Life Evidence: Broken POP chunks settle on corals, seaweed beds, and benthic organisms. Impact: Suffocates marine life by creating an artificial seabed cover. Example: Bombay Natural History Society (BNHS) documented marine life deaths in Mumbai's Girgaum Chowpatty region post POP immersion.

events. Plaster of Paris idols have been a common choice for Ganesh Chaturthi celebrations due to their affordability and ease of molding. However, PoP is derived from gypsum, a nonrenewable resource, and its production involves harmful chemicals. Moreover, PoP idols do not dissolve easily in water, leading to pollution and harm to aquatic ecosystems when immersed in water bodies.

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RECOMMENDATIONS

This research highlights that reviving traditional practices during Ganesh Chaturthi—especially the use of clay idols—offers a meaningful path toward environmental sustainability. The study confirms that clay idols, being biodegradable and non-toxic, significantly reduce water pollution, support soil health, and protect aquatic ecosystems.

In contrast, modern materials like Plaster of Paris, chemical paints, plastics, and glitters contribute to long-term ecological damage, threatening marine life, degrading water quality, and harming human health. The decline of traditional pottery and the commercialization of the festival have further distanced communities from eco-conscious rituals.

Yet, the growing awareness among youth, increased community participation, and initiative-taking NGO efforts shows promising signs of change. If supported by strong policies, education, and cultural renewal, Ganesh Chaturthi can once again reflect harmony between devotion and nature.

Preserving the festival's spiritual essence while adopting ecofriendly practices is not just a cultural necessity, it is an environmental imperative.

Further research can be done in accumulation of garbage on the river beds during dry seasons.

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