APPLICATION OF ECONOMIC INSTRUMENTS IN MARINE DEBRIS CONTROL

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Abstract-Marine debris, also known as marine litter, marine garbage and ocean debris and it is defined as, any manufactured or processed solid waste material that enters the marine environment from any source whether on land or at sea. Marine debris is an avoidable cost. Preventing debris entering water courses will therefore reduce the economic impact, including clean-up costs. This paper deals with types of marine debris, and their impact on marine living organisms. It outlines the features of marine economy, and impact of marine debris on marine economy. This paper makes a special note on application of economic instruments in marine debris control. This paper concludes with some interesting findings along with policy suggestions.

Key words: **marine debris, clean-up costs, marine debris control, economic impact, cost benefit analysis.**

Introduction

Marine debris, also known as marine litter, marine garbage and ocean debris, and it is defined as any manufactured or processed solid waste material that enters the marine environment from any source whether on land or at sea. Research suggests that 6.4 million tonnes of debris reach the world's oceans each year, and that around eight million items enter the sea every day. Plastics consistently comprise 60 to 80% of total debris recorded. Levels and rates of debris input are increasing despite measures to control the problem. Globally, as much as 80% of marine debris entering the ocean each year is thought to come from land-based sources, with the remainder arising from shipping and other maritime sources.

Marine debris is an avoidable cost. Preventing debris entering water courses will therefore reduce the economic impact, including clean-up costs. Simple debris stock-flow models confirm that intercepting debris early in the marine debris cycle, prior to dilution at sea, can reduce the damage cost.

Types of Marine Debris

Industrialized society generates solid wastes in many forms, as goods are transported, sold by retailers and used by consumers. Some of the waste finds its way to the oceans where it ends up as marine debris. According to Sheavly (2005)[1] debris is ubiquitous in the world's oceans, and is now recognized as one of the most insidious pollution issues facing our oceans. Sheavly (2005)[2] and Allsopp et al. (2006[3]) point out that over the past 50 years, the nature of disposed waste has changed and organic materials, which once comprised the majority of discarded wastes, have largely been replaced by synthetic materials which are durable and may persist in the environment for many years. In addition, many synthetic materials are buoyant and can be transported over large distances, impacting on environments a long way from their point of origin.

UNEP (2005[4]) suggests that on average, 13,000 pieces of debris are floating on every square kilometre of ocean surface. Uneputty and Evans (1997)[5] and UNEP (2005[6]) report that the despite efforts made across regional, national and international scales the problem of debris continues to increase. There are a wide variety of items that become debris in the ocean. According to Fanshawe and Everand (2002)[7] the main types of debris found in the ocean are as follows. These include plastics (fragments, sheets, bags, containers), polystyrene (cups, packaging, buoys), rubber (gloves, boots, tyres), wood (construction timbers, pallets), metals (beverage cans, oil drums, aerosol containers), sanitary or sewage-related items (condoms, tampons), · paper and cardboard, cloth (clothing, furnishings, shoes), glass (bottles, light bulbs), pottery/ceramic, and munitions (phosphorous flares).

Allsopp et al. (2006) bring to attention that all the debris types listed above, plastics consistently comprise 60 to 80% of total debris recorded in marine debris surveys. Derraik (2002[8]) points out those plastics have become extremely important in modern society, and usage has greatly increased over the past three decades. Plastics are lightweight, strong, durable are cheap to produce, and it is these properties that make plastic such an issue in the marine environment. Plastics pose a great threat to marine systems as once released into the ocean they do not degrade and may persist in the environment for many years. In addition, many plastics are buoyant, and therefore can be travel great distances.

The prevalence of plastics can be seen in shoreline and recreational activities. In the ocean and waterways debris categories, ropes, fishing lines and plastic sheets are most frequent, but are followed by a range of ancillary categories of commercial fishing items. Though low in number, building materials, batteries and car parts make a significant contribution to the volume of debris.

As per the report by Kiessling (2003[9]) derelict fishing gear is another type of marine debris. It enters oceans either accidentally during the course of normal operations by the way of storms or through entanglement on reefs or through deliberate dumping. Most modern fishing gear is constructed of synthetic materials and is relatively inexpensive. Therefore, there may be an economic incentive for fishermen to discard gear rather than spend time in repairing old or damaged gear. Derelict fishing gear causes severe problems through entangling larger fauna such as seals and turtles, and through damaging sensitive habitats. In addition, it can pose a navigational hazard or cause damage to vessels through collision, or fouling of water intakes and propellers.

Floating Debris

Floating debris generally comprises plastic bags, plastic items and woody debris, and it may be transported by currents and winds over great distances before sinking or being cast ashore. Marine organisms such as seals, birds and turtles can become entangled in, or ingest floating debris. In addition, floating debris poses a risk to vessels which may be damaged through collisions with larger debris such as cargo containers and oil drums, or by having ropes and nets foul propellers and water intakes leading to engine damage. Johnson (1989)[10] and Kiessling (2003) bring to focus that in more remote locations; floating debris from commercial fishing operations is often washed ashore and may cause significant problems to local wildlife.

In addition, a large volume of litter from land-based sources remains on beaches, and in coastal habitats. General litter such as cigarette butts, paper, food wrappings often makes up most of the items in beach clean ups. Wagner (1989[11]) warns that debris on beaches and shorelines poses problems to wildlife and local tourism, and potentially presents a hazard to the health of beach goers. Loss of amenity on beaches and in shallow coastal habitats can cause significant economic impacts.

Seabed Debris

Moore and Allen (2000)[12] bring to focus that seabed debris are the heavier types of debris may sink when discarded and come to rest on the seabed or become incorporated into soft sediments. Moore and Allen (2000) and Lee et al. (2006)[13] reveal that debris on the seabed is very often derelict fishing gear, metal, cans and plastics, mainly from vessels and fishing activity. Debris on the seabed poses a threat to sensitive habitats such as coral reefs which can be damaged by fishing gear and other forms of debris.

Wildlife Marine Habitats and Ecosystems

Marine debris also has an impact on wildlife, marine habitats and ecosystems. The ecological impacts of marine debris have been extensively studied in all but the deep oceans. These impacts include injury and death of wildlife through entanglement and ingestion, and the destruction of fragile habitats such as coral reefs, and the potential spread of invasive species. Derraik (2002[14]) suggests that as many as 40,000 Northern Fur Seals may be killed in the Bering Sea annually through entanglement in plastic debris. While marine debris damages environmental amenity, it also has direct economic impacts. It could be observed that the death of marine animals from ingesting or becoming entangled in debris is a loss of natural capital. Habitats such as coral reefs can also be damaged by physical abrasion, being covered or being negatively impacted by chemical residues. Derelict fishing gear can become entangled on corals, and can abrade the delicate skeleton.

Plastic debris probably has most impact on the marine environment. Plastics enter the marine environment in the form of waste plastic bottles or containers, and they gradually deteriorate over years and decades to become pieces and eventually small plastic fragments. These can be ingested by marine mammals, birds, fish and benthic life and remain in the animals. Marine debris can also be part of the introduction of invasive species. Any floating object in the ocean is capable of distributing species into non-native habitats. Dispersal of invasive species has been greatly increased by the introduction of large quantities of floating plastic which can act as 'rafts'. The presence of invasive species can have devastating ecological consequences to local marine communities. Barnes (2002)[15] suggests that biological invasions pose one of the greatest threats to marine biodiversity. In addition, the cost of cleaning or removing invasive species and the potential loss of fisheries can have serious economic consequences for coastal human communities.

Ghost Fishing and Derelict Fishing Gear

Lost fishing nets, such as gill nets, can 'ghost fish', continuing to trap fish until they have settled and become ineffective. They do not readily break down and can entangle wildlife and rocky habitat such as reefs including corals. Laist (1987)[16] and Laist (1997[17]) report that worldwide, at least 267 vertebrate species have been affected by becoming entangled in derelict fishing gear or plastic packaging, or through the ingestion of plastic debris. This includes 86% of all sea turtle species, 44% of all sea bird species and 43% of all marine mammal species. It is likely that this is an underestimate of the number of species affected by debris, as many would die and sink or are consumed by predators before being observed. As per the report by Donohue et al. (2001[18]) during periods of wave action, debris can cause corals to break. If left in place for long periods, debris can be incorporated into the reef structure.

Pooley (2000[19]) urges that costs of disposing of fishing gear can be high, so fishing gear is sometimes dumped as a low cost disposal method. Proper disposal can be encouraged by providing low cost reception facilities and this would also lower the amount and impact of debris.

Impact of Marine Debris on Marine Economy

Marine debris may potentially have a negative impact both on the economies of industries using the oceans and on the economic values of the ocean itself. The value of the marine economy has been investigated by several projects and these studies indicate the economic value being generated by activities associated with the oceans. It is significant to note that direct, indirect and non-market economic impacts of marine debris have been observed and economic costs are lost benefits to society. Faris and Hart (1994[20]) held the view that the economic impacts of marine debris can be measured by the diminished opportunities to exploit the marine environment for pleasure or profit. Impacts can have either direct or indirect costs. The different categories of economic costs in the marine debris are as follows:

It is observed that direct economic costs are those costs which arise from damage to an industry or to an economic activity, for example the costs of vessel downtime due to marine debris entanglement on a vessel propeller. These costs are readily measured. Indirect economic impacts are those costs which arise indirectly, from marine life ingesting plastic waste and contaminating the food chain, therefore impacting on fish and even humans. These costs are not so easily measured.

Non-market values: those costs which arise when marine debris compromises nonmarket values such as scenic values, or the values placed on the marine environment, or marine activities by people who do not necessarily access them. Faris and Hart (1994) warn that marine debris is of concern to the community and there can be a willingness to pay, even on the part of non-users, to have the beaches cleaned. It could be noted that the levels and value of recreational activities in the marine environment are reduced by marine debris. Beach goers finding a variety of marine wastes on beaches will reduce their visits, or length of stay, with losses to tourism in the local economy. Measuring such non-market losses is not straightforward, as visitors may travel to another beach that has no marine debris, and it is the relative loss between beach sites that determines the loss of economic value.

When seeking to remedy the marine debris problem, costs of prevention and cleanup should be considered. Prevention can involve waste management schemes, technical intervention and regulations. The costs of cleanup include expenditures to remediate coastlines, beaches and ports impacted by marine debris. Values can also be measured for non-market impacts such as the impacts of plastics on marine animals. This would require specific non-market valuation studies of the costs of harm to and reduction of populations of various marine species.

Fishing Industry

Hall (2000)[21] and Takehama (1990[22]) bring to attention that the fishing industry is particularly impacted by marine debris. There have been several studies of the marine debris damage to fishing boats throughout the world. In Japan, Takehama (1990) estimated the cost of damage to fishing vessels caused by marine debris, based on insurance statistics available through the Japanese fishing insurance system. Such damage includes accidents, collisions with debris, entanglement of floating objects with propeller blades and clogging of water intakes for engine cooling systems.

Transportation Industry

Marine debris is known to be a hazard to marine vessels in various ways. Floating containers are a navigational hazard to coastal and ocean shipping, and derelict fishing gear and ropes may represent a threat to fishing and smaller vessels. Entanglement with ropes has on occasions led to propeller damage and sinking of vessels via stern tube damage causing an influx of sea water.

Tourism Industry

Marine debris such as ropes, plastics and derelict fishing gear can end up on the seabed, on beaches and along the coastline. This negatively impacts the aesthetic values of the coastline and beaches for marine tourism visitors and residents. This can translate into a reduction in the amenity value of beaches for tourists and may mean that tourists will be less willing to pay to go to a tourist location.

The perceived loss of amenity can cause consumers to move to other beaches and coastal areas with a loss of expenditure to the region. The economic loss to the whole economy considers the relative change in values by consumers using a substitute beach. Marine debris is a concern for municipalities when tourists go elsewhere, manifesting as a loss in the local economy. On an international scale, tourists may chose between holiday locations in different countries on perceptions of aesthetic coastal values. The importance of tourism expenditure in many economies may provide the private sector with an incentive to contribute to keeping the beaches clean. Given the importance of marine tourism to many national economies, national governments should also see beach litter and marine debris in the sea as prejudicing their marine tourism industries.

The Costs of Control

The total annual costs of prevention or clean up of marine debris increase with the amount of prevention or clean up activity being undertaken. The cost of a sustained reduction in the stock of debris by one unit, either through a sustained program of prevention, or of clean up activity, is referred to as the marginal cost. The marginal cost of prevention or clean up increases with the level of activity. As more and more debris is prevented from joining the stock, the cost of preventing the addition of another unit of debris to the stock rises; and as the stock of debris declines, and debris becomes more inaccessible or harder to locate, the cost of cleaning up an extra unit of debris also rises. A cost effective program of reducing the stock of marine debris would strike a balance between the levels of prevention and cleanup activities which equated their marginal costs. Such a balance would ensure that an extra dollar/INR of program expenditure would have the same impact on the stock of debris irrespective of whether the dollar/INR was allocated to prevention or to clean up activity.

Economic Decisions and the Control of Marine Debris

Often the economics of marine debris control is over simplified to an assessment of finding the lowest cleanup cost per tonne. The economic decision to intervene with clean up action is often made from necessity with little consideration of alternatives. In the longer term, it is desirable to compare the benefits from spending additional funds on prevention. This will take cooperation on a wider area or national scale. The stock flow approach indicates that when the total stock of marine debris is low, then a local approach may be adequate, but this will become more expensive and more inefficient as global debris stock grows.

Economic Costs and Benefits and the Control of Marine Debris

The cost of cleaning up marine debris is important in developing economic strategies for controlling marine debris. Marine debris is not a uniform waste product and the cost of cleanup varies with the type of debris, the location and the methods used. Clean up costs are expressed in dollar/INR per cubic metre, dollar/INR per kilometre of coast or beach, or preferably dollars per tonne.

Benefit-Cost Analysis

Benefit-cost analysis is a technique for undertaking an economic appraisal of a proposed project or program. Any expenditures on scarce resources, whether of a capital or recurring nature, involve an opportunity cost—the value of the goods and services which the scarce resources could have produced in alternative uses. The benefit-cost analysis compares the value of the output of the project with the value of output which the resources involved could have produced in their alternative uses. Benefit-cost analysis relates to economic and environmental impacts analyses. First, an economic impact analysis measures the effects of undertaking a project on GDP or gross regional product (GRP). All expenditures have an impact on economic activity (GDP or GRP) through the market system and the associated multiplier effect, but these expenditures should not be confused with net benefits.

An environmental impact statement is a detailed analysis of the physical effects of the proposed project or program. Examples of these effects include changes in pollution levels, habitat extent, and wildlife populations, expressed in physical units such as percentage of dissolved oxygen, hectares, or biomass. While measured in physical units, these changes affect economic welfare and should be included in the benefit-cost appraisal in terms of dollar/INR costs or benefits, an issue which will be discussed further.

Benefit-Cost Analysis and Marine Debris

An economic appraisal reveals whether the value of the benefits of a proposed project or program exceeds the opportunity cost. In other words, it indicates whether allocating resources to the project generates more value, in terms of the project output, than the value the additional goods and services the resources would have produced in their alternative uses. The appraisal can also contribute to the design of the proposed project; to maximize the net value of the project or program its various elements should be extended to the point at which marginal benefit equals marginal cost, but not beyond that.

In calculating the marginal cost and marginal benefit for comparison, the inclusion of non-market and other values in the analysis must be addressed. A pragmatic approach in a world where little such comparison is undertaken is to start with market costs and see where the optimum level is. The inclusion of more non-market values will increase the marginal benefit and give an analysis with a lower target debris stock level. A benefit-cost analysis of a program of reducing marine debris starts by identifying the benefits and costs. The benefits consist of ‘avoided costs’—the reduction in costs imposed by marine debris which will occur as a result of the reduction in the volume of marine debris achieved by the program. Such cost reductions include lower costs to shipping, fisheries, and recreationists as well as more general environmental costs associated with damage to coastal ecosystems.

Some of the costs of prevention or removal of marine debris can be measured by market prices. It could be noted that an expansion of refuse collection and storage facilities may involve improved storm water disposal systems, more landfill sites, and storage facilities on vessels and at docks, while removal of debris will involve labour and equipment. These costs of the program, consisting of the opportunity costs of the scarce resources involved, are generally measured by the market value of the resources allocated to the program. In some situations resources may be over-priced in terms of otherwise unemployed labour or under-priced in the form of carbon emitting fuels) by the market, and will need to be shadow-priced in the program appraisal. Other costs are not directly measured by the market although market prices may allow an indirect measure to be generated. Less readily measured by market prices are the adjustment costs faced by consumers when, for example, they substitute reusable bags for plastic grocery bags.

Having identified the types of benefits and costs involved, a benefit-cost analysis of a program of marine debris removal would proceed to value these in dollar/INR terms. Some outputs or inputs would be valued at market prices, some would be valued at market prices adjusted for those imperfections which drive a wedge between market price and marginal benefit or marginal cost, and some would be valued using non-market valuation techniques based on revealed or stated preference approaches. The economic incentives to control marine debris come from the fact that debris is avoidable, and therefore damage and clean up costs can be reduced. Stopping debris entering the marine environment has a double cost saving. Economic instruments can be part of the measures to control marine debris, being potentially most effective in addressing prevention of debris. Much of this marine impacting activity requires policy changes on land.

Economic Responses to Marine Debris Impacts

Stavins (2003)[23]; Martin (2006[24]), point out that there are different approaches to controlling environmental issues. These involve regulation (authority), market instruments (exchange), community (persuasion), management measures, and imposition of technical and operational procedures.

Regulation of Marine Debris

Regulation has been the favored approach of governments in reducing marine litter due to the public good and common property nature of the debris in the sea. Martin (2006) reports that in the last two decades market instruments have been introduced to analyze the environment and resource management planning, problems and policy responses. Some market instruments have been used in controlling marine debris, although there is limited literature on this method. The community has been encouraged to be involved in public beach clean-ups by NGOs.

Economic Instruments

Using economic instruments to control marine debris has received relatively little attention, possibly due to the avoidable cost nature of the issue which may lend itself to regulation, rather than the remedial use of economic instruments. In many areas of policy, market-based instruments are developed to use the market mechanism to create incentives and disincentives to bring about more positive environmental outcomes. Stavins (2003) points out that ‘market-based instruments allow any level of pollution clean up to be realized at the lowest overall cost to society’. ‘Most applications of market-based instruments have been at the input or emission point of regulatory intervention, although few have focused on ambient concentrations’. Wide based source pollutants are more difficult to address due to the disconnect between the pollutant and the source or sources. Marine debris is impacted by this non-point-source issue.

Conclusion

It could be seen clearly from the above discussion that the use of economic incentives to control waste practices on land is gaining momentum and is now being extended to the control of marine debris. However, in many cases improved land debris control practices would also benefit the marine environment. Linkages in management measures and between these issues need to be strengthened, as does establishing collaborative relationships between the different institutions with management and legislative authorities. There are some limitations on the applicability of market-based instruments to marine debris control. As marine debris is a non-point-source pollutant, some instruments such as effluent charges are not automatically feasible. There have been few market based instruments that have been used directly to control marine debris. The existing instruments tend to be applied in the management of land debris. The potential of each market-based instrument to be involved in the control of marine debris and it should be examined for their potential to control marine debris.

There is a need to introduce deposit-refund systems, user and administrative charges, sales taxes and cost sharing. Deposits-refund systems A deposit system on drinks containers can have a refund condition to minimize the loss of containers to debris. Deposit systems can also ensure 100% recycling while reducing marine pollution. This also transfers the cost of reducing litter to the drinks manufacturer. This could be implemented to prevent marine debris.

User and administrative charges marine debris can be charged at a fixed amount, or on a 'pay-as-you-throw' system, where users pay in proportion to the volume of their waste and the marine environmental damage.

Sales taxes can be applied to products with environmentally damaging contents such as ozone depleting chemicals etc. Taxes on plastic bottles and plastic containers could reduce the use of plastic, and force innovation in alternative cardboard packaging. For shipping, implementing payment of a fee at port for vessel rubbish reception, whether it is used or not, may ensure use of the reception facilities. Sales taxes on other disposable items commonly found in marine debris could be considered such as plastic containers, aerosols etc. The government should implement activities towards reucing marine debris.

Cost sharing agreements are made between parties to divide the total cost of a future course of action into proportions to be paid where a municipality and a port authority agree to divide the costs of debris clean up equally, or by some other agreed percentage, for the coming year.

In the case of credit programs, in practice a marine environmental or marine debris control scheme, government can give credits for environmentally beneficial behavior. Marine debris prevention could be included in such a scheme.

An offset is a positive environmental action on an alternative location that counterbalances the environmentally degrading issue at a given environmental site. The offset action can be contracted to another party to perform. Total environmental outcomes can be achieved at lower cost than by on-site mitigation.

There is a need to Levering private investment cleaning up marine debris may also create commercially attractive benefits to private investors in beaches and tourism able to gain from a differentiated product, such as a clean beach.

In marine debris control, Liability rules and risk can be tackled. In industries with insurance and risk, such as shipping and fishing, the adoption of industry practices to reduce the risk of damage from marine debris can reduce insurance premiums.

A marine tourist resort may advertise a clean 'no marine debris resort area'. This can provide a commercial premium, and maintain and improve visitation rates.

Efforts could be made aim at reducing the marine debris stock level once debris is in the inshore, offshore and ocean arena, the main monitoring tool is the ambient level of the marine debris stock and whether there are 'hot spots' where litter gathers. Similarly the flux, or turnover of debris after removal, can be measured at a given site to indicate the local abundance debris. Knowledge of stock levels and marine debris deposits is important if governments decide to 'go fishing' to clean up marine debris aggregations.

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