KYSTVERKET

Norwegian Coastal Administration

Experience from the plastic pellets incident Trans Carrier, focusing on shoreline clean-up methods

21 December 2020

Summary

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Sammendrag:

Opprensing av plastpellets er absolutt mulig, men det er tidkrevende og omfattende. Det er viktig med gode befaringer som etterfølges av snarlig opprydning.

En kartløsning ble brukt for registrering av påslag og opptatt mengde, samt til visning av fremdrift i rensearbeidet.

Støvsugere, løvsugere og sålding er metoder som har fungert tilfredsstillende og ble mye brukt. Der det var store ansamlinger av pellets ble sugebil benyttet. Gravemaskin, i kombinasjon med vannbad for å skille pellets, ble brukt på en strand og fungerte effektivt.

Det er viktig å prøve nye metoder, og ha fokus på teknologiutvikling og spesielle maskiner/redskaper som kan brukes.

Kost/nytte vurdering er viktig med hensyn på rensenivået.

Summary:

Clean-up of plastic pellets/nurdles is certainly possible, but is time consuming and extensive. It is important to survey thoroughly, followed by a clean-up shortly afterwards.

A mapping software was used to record locations of stranded nurdles, progress in clean-up operations and amount of collected nurdles.

Different vacuum cleaners and sifting methods worked satisfactorily and were widely used. Suction trucks were used to remove large accumulations of nurdles. An excavator, in combination with a water bath to separate nurdles, was used at one site and worked efficiently.

It is important to test new methods, and focus on technology development and special machines/tools that can be used.

Cost/benefit assessment is important with regard to the level of clean-up operation.

Origin language of the report: Norwegian

Contents

1 Introduction

A container on the deck of the ship Trans Carrier was damaged, with the result that 13.2 tonnes of plastic pellets (also known as nurdles) went into the sea. The incident occurred on 23 February 2020 in German and Dutch waters in the North Sea. This polluted a large area, from the west coast of Sweden, along the Oslo Fjord and down along the coast of southern Norway as far as Tvedestrand. In Norway, the largest finds of pellets were in the counties of Østfold and Vestfold, with more being found in Østfold than in Vestfold.

The local authorities and volunteers started the clean-up in March 2020. The first organised clean-up was in the middle of March in the municipality of Fredrikstad. It was performed by Coastal Management Services (Skjærgårdstjenesten) and the Oslofjord Recreational Outdoor Council (Oslofjordens Friluftsråd). A number of parties put a considerable amount of work into the clean-up, while a search went on for the source, which was not known at the time.

On 7 May 2020, a national response operation led by the Norwegian Coastal Administration was declared to handle the incident. This was after the Ministry of Transport and Communications issued a clarification in early May 2020 that the incident was covered by the definition of acute pollution pursuant to section 38 of the Pollution Control Act.

In this incident, Inter-municipal committees against acute pollution (IUAs) mainly inspected and mapped out the affected areas, while volunteers coordinated by the Oslofjord Recreational Outdoor Council (OF) handled the clean-up of the areas identified by the IUA in Østfold, Inner Oslo Fjord, Buskerud and Vestfold. Since OF does not operate in the counties of Telemark and Aust-Agder, the IUAs in these areas had a bigger clean-up job than the four other IUAs involved. The Norwegian Coastal Administration's staff have also been involved in inspections and clean-up.

The purpose of this report is to gather together experiences from the clean-up operation, with particular focus on practical experience and methods used in the clean-up work. We gathered together representatives of all those who had been involved in the clean-up work for a one-day meeting. Here we discussed and compiled experiences, and this forms much of the basis for this report. We have also received useful input and photographs from those who were out performing the clean-up operation.

Figure 1. Plastic pellets in nature.

2 Inspections

Inspections were largely performed by the IUAs involved, while the Norwegian Coastal Administration also performed some inspections. Experiences from the inspections were:

- The pattern of currents is important for where the pellets end up. On the Østfold side of the fjord, pellets were mainly found in bays facing south and south-west. In Vestfold the plastic pellets were mainly found in north-facing bays, although in bad weather south-facing bays were also affected.
- In bad weather and in the case of early deposits, plastic pellets were washed up far beyond the edge of the beach.
- Pellets have a low specific gravity and are affected by the wind. Pellets are moved around on hard surfaces when there is no vegetation.
- Pellets usually accumulate in a narrow belt above the high-water line.
- If pellets are among vegetation they will stay in position longer. Plant growth prevents pellets from moving around.
- In protected areas, inspection was postponed because of the bird life. This divides up the inspections, but was considered appropriate on the basis of a total environmental assessment.
- A check should be made for plastic pellets in those spots along the coastline where a great deal of other rubbish tends to accumulate. Some local authorities perform their own mapping of marine waste, which is useful in this context.
- Heavy rain tends to move pellets down towards the sea. Inspections after heavy rain must take this into account.
- On beaches, pellets were often found at both ends of the beach, not evenly distributed along the whole beach.
- Findings from inspections must mainly be considered as having a limited “shelf life”, since the situation can be changed by strong winds, heavy rain and high tides.

It is important for the clean-up to start shortly after inspection, because of the remobilisation of pellets. It is vital to mobilise clean-up efforts quickly before the pellets have time to spread. Biological material can become attached to pellets, causing them to become heavier and sink. It was also found that areas that had been cleaned up can have new deposits. This is a problem and it can be assumed that new deposits will continue to come. There are often new deposits in spots where a great deal of other rubbish tends to accumulate and also deposits on beaches tend to move around. Where deposits of pellets have been recorded, this does not mean that they will still be there if a clean-up operation is started later.

Cleaning up pellets is most effective in dry, warm weather. However, it is still possible to clean up pellets in autumn and winter, as long as there is no frost or snow covering. Wind, rain, snow and frost can be a hindrance to the work. Cleaning up in autumn and winter causes less disturbance to flora and fauna. After the first frost, much of the vegetation will die back, making the pellets more visible and enabling a clean-up. A list of hot spots has been drawn up that should be monitored, with new inspections until spring 2021. These, for example, are exposed areas where there have been considerable deposits on several occasions. New deposits are most often found in the seaweed and kelp belts.

Areas that appear at first sight to have large deposits may not necessarily have these. Areas where pellets are spread around on the surface of the beach may appear to have much more than they have. Other areas where deposits do not appear to be too bad can have large quantities of pellets under stones or in among the grass. Experience shows that pellets are very often found on both sides of a beach.

It is therefore important that those performing an inspection know where on the beach they should start to look, and they should also check whether the pellets are only on the surface or whether they may be hidden in sediments, among the pebbles or in vegetation. Some pellets had become buried, but mostly they were in the top 10-15 cm.

3 Methods

3.1 Sieving

Sieve boxes were made in various sizes and shapes and from different materials. There were wooden boxes with long handles, modified plastic buckets and sieves. A sieve box was mounted on the underpart of a wheelbarrow so that the wheel made it easier to move around.

Figure 2. Sieving with a wheelbarrow.

Figure 3. Filling a sieve box.

A prototype sieve box with a motor was also made to shake the sieve automatically. This simplified the manual process and speeded up sieving. However, the prototype was heavy to transport and somewhat time consuming to set up, so that it remained standing in one place on the beach. This sieve needed a generator and petrol. A good deal of work was needed to transport contaminated sand to the sieve and then spread the sieved sand back again. An improved version that is lighter, more mobile and easy to make steady and stable would probably be a much more effective aid.

What all the sieves had in common is that they worked well, but there were problems when dealing with damp material. Seaweed and kelp should be removed first, if possible. Damp sand clings to the pellets, which can be improved by mixing dry sand in with the contaminated material. It was also easier to sieve material if it had been collected in a vacuum cleaner first. The top layer on the shoreline is the driest, so it is sensible to use a sieve on this. Besides pellets, many other things are collected in the sieve, such as gravel, twigs and so on. These can be separated out with a water bath, or everything can be delivered to a waste centre as "other waste".

Different sizes of mesh and chicken wire were tested. Some time was taken over finding the right size. The experience was that a metal mesh worked better than plastic. Plastic netting falls apart more quickly, although a disadvantage of metal is that it can rust. There will be a need to replace the netting.

Figure 4. Sieve box with one person working on each side.

Having two layers with different mesh sizes works well, but the lower part must not be over-filled. A test was also made with three layers, but this gave no improved effect. There were problems with the weight of the material causing the netting to sag. This resulted in wear of the netting. Extra battens were put in to reinforce the netting. Many types of netting were tried, but there is still room for further work on the quality of the netting, as well as testing solid sheets with holes.

Shaking the sieve boxes is very hard physical work. Handles on the sieve boxes worked well. Double handles did not work; they were no more effective. It also worked well to kneel and take hold of the frame (not the struts). Whatever type of sieve is used, you must use your hands to push the material through the mesh.

Adjustments needed to be made to the sieve boxes for optimum function. The size should be large enough to enable the vacuum cleaner bag to be emptied. In other places where no vacuum cleaner is used, the sieve does not need to be as big. Which sieve box works best depends on the situation, but all were fit for purpose.

It is important to save the work drawings for the sieve boxes so that it will be easier to produce them when they are needed for the next response operation. Sieves were set out on the shoreline for local community associations to use for cleaning up and these were well received. Gloves, dust masks and protective eyewear should be used when sieving.


Figure 5. Remains in a sieve box after sieving.

3.2 Vacuum cleaners

Different types of vacuum cleaners were used. They work very well on dry material and gravel. They do not work so well on fine sand because they pick up too much sand. There is a filter to separate out the sand, but it soon becomes blocked. The filters were therefore seldom used. There are also vacuum cleaners available with filters that can separate out sand and gravel. When battery powered vacuum cleaners are used, there must be several replacement batteries, as well as a generator so that they can be charged. To have continuity in the work, good logistics are important here.


Figure 6. Pellets before vacuum cleaning.

Rucksack-style vacuum cleaners work well because they are easy to carry around in the terrain. Having several nozzles makes the job easier, to be able to adapt to small fissures etc. It is an advantage for nozzles to be flexible. When choosing a vacuum cleaner, it should be one that is easy to clean.

Figure 7. Using a rucksack-style vacuum cleaner.

Figure 8. Collected pellets.

It can be useful if one person goes ahead to clear and check the area and use a rake before another comes with the vacuum cleaner. Some beaches have sand or small stones the same size as the pellets and here a water bath can be used to get rid of smaller stones and larger grains of sand. A combination of methods proved to be effective.

Figure 9. Emptying the rucksack container into a sieve box.

Figure 10. After sieving, a bucket water bath is used when the particle size is similar to the pellets.

Figure 11. Shows an area after removal of pellets.

3.3 Leaf vacuums

Leaf vacuums worked well on smooth rocks and beaches and in wetland areas. They are very useful where there is a large quantity of pellets, but not in pure sand. A petrol-powered leaf vacuum is easy to take around and has enough power for suction. It will run for a long time on one tank of petrol. Note that the machine is hot when it is put down. When battery powered leaf vacuums are used, there must be several replacement batteries, as well as a generator so that they can be charged. For continuity, good logistics are important here.

Figure 12. Using a leaf vacuum in fissures and between stones.

Some reported good experiences with modified leaf vacuums with collection bags that separated pellets and sand. The disadvantage here is that it becomes very dusty and the mesh can be ruined after use.

The material of the tube varies from manufacturer to manufacturer. Flexible tubes work best since they can be got into fissures and small spaces. A good technique for getting the pellets in is to pull the tube backwards. Another method is to turn the equipment on and off. Finding the right interval is a matter of trial and error, but the aim is that stones and gravel are not sucked in but fall out every time the vacuum is stopped. Pellets are lighter than stones and gravel and will be sucked in.

In areas with wet soil, it was crucial for one person to have the job of taking the leaf vacuums apart to clean out soil and other material that was stuck in the chamber around the paddle wheel. Suitable tools for each leaf vacuum and for scraping out soil must therefore always be taken into the field as standard equipment.

Tubes can be fitted the wrong way and it was found that it was difficult to disassemble them, making the work harder. Using a leaf vacuum can mean a difficult and burdensome working posture. A shoulder strap makes carrying easier, but it is important to take frequent breaks. Battery-powered leaf vacuums make less noise and are suitable where there is a risk of disturbing people or wildlife.

3.4 Suction vehicles and other equipment

Where there are large quantities of pellets, using a suction vehicle is very effective. Suction vehicles were used at the start of the resonse operation. At that time, there was a high concentration of pellets lying in clearly visible zones. Using a suction vehicle requires some skill from the person operating the nozzle, so as to avoid vacuuming up material other than pellets. With a good technique, it is reasonable to assume that up to 90% pure pellets can be obtained from an area with a high concentration. Pellets that have gathered into heaps can be expected early in a response operation and here it is vital to get going as quickly as possible before the pellets are remobilised and spread over larger areas. For a suction vehicle to be used there must be a road down to the shoreline, or a barge can be used.

Figure 13. Reier beach in Moss municipality. Here a suction vehicle is being used.

The PortBin ShoreCleaner fills a role between vacuum cleaner/leaf vacuum and suction vehicle, in that it has better suction power and more collection capacity than a vacuum cleaner/leaf vacuum. The disadvantage is its size and weight, but it is more flexible than a suction vehicle. ShoreCleaner has wheels fitted but also fits into a trailer on an ATV. The Coastal Management Services (Skjærgårdstjenesten) boats proved to be suitable for transporting ShoreCleaner directly into the area to be cleaned up.

Figure 14. PortBin cleaning up pellets and paraffin wax.

There is other equipment available that is designed for removing granules from artificial football pitches. This resembled a big vacuum cleaner and will be dependent on being transported on a truck or similar. If there is a large job that can be accessed with a vehicle then this may be suitable, but an ordinary suction vehicle could be used just as well.

3.5 Water bath

There was an attempt to mount a water bath on a car trailer. This did not work in this case, partly because there was little difference in colour between the plastic fabric underlay and the pellets.

Water baths were also made in large black buckets. For these, the material must be placed in them carefully. This works in some cases. It is important not to put too much material in at once and it is a good idea to sieve the material before it goes into the bucket. Two bricklayer's buckets were also used, one on top of the other. The top bucket has holes, so that the sand falls into the lower bucket. Left in the top bucket are pellets, which float, and stones which lie on the bottom. The material in the bucket must be stirred around to get the pellets to float up. A sieve or mesh net is used to remove the floating pellets.

Figure 15. Emptying a vacuum cleaner bag straight into a water bath.

Water baths in or beside existing pools work in the same way and were used where pellets were buried in the beach. The method was to pull the material down into the water and throw water onto the material so that pellets floated in the pool. Then stones had to be pulled out to get enough depth to remove the pellets with a net or sieve. The disadvantage is that all the floating material (small sticks, feathers, rushes etc.) comes with them. It is possible to sieve this afterwards, but this causes problems because everything is wet and it takes an unreasonable amount of time. It is more effective to take away the pellets along with everything else that come in the net.

Figure 16. Material with pellets before the clean-up work has started.


Figure 17. Material is moved to the water bath.


Figure 18. After the work; the blue sack contains the collected contaminated material.

3.6 Trap system from streams/pools

Such systems work on beaches and gravel. They are typically used on larger, sandy beaches. An excavator cleans up the beach quickly and the method appears to be very effective there.

An attempt was made to construct a trap system in a stream, but these collected up a lot of material and it was not easy to see the pellets. This was a good lesson learned for developing a larger trap system.

Figure 19. Damming a stream to trap pellets.

Figure 20. Trap system where a lot of material has been collected.

Two pools were dug to a depth of about 2 metres and a short distance apart. There was a rough separation in the first pool and a finer separation in the next one. It was later found that one pool was enough.

This was an effective method for cleaning up a large area in a short time. An excavator dug out the contaminated material and placed it carefully in the pool. The excavator has a large capacity and could have handled more pools. The pellets were removed by hand, using a net. This was a heavy physical job. The pellets were filled into intermediate bulk containers. The material taken up was estimated to be 5% pellets. This method was used on a contaminated area of about 200 metres of beach.

The surface area of the pools determined how much material could be put in at a time. The water supply in the stream is also decisive and the volume of this was controlled by opening and closing hatches in the watering reservoir above the stream. As far as the pool is concerned the volume of water supplied could have been greater, but this could lead to turbulence and a speed of current that would pull pellets under the boom. When it was adjusted correctly, few pellets got away and few pellets were carried to the bottom. It was important to ensure that there was not too much material in the booms. In this case both pools were dug out again after 4-5 uses. This material was removed and returned to the beach.

The excavator used different kinds of buckets, depending on the type of material. In some places, pellets were found down to a depth of 2-3 metres, but in most cases they were in the top 10-15 cm.

In this response operation, a natural stream was used. However, such systems could also use water pumped from the sea.

The use of the excavator is very effective and in this response operation there was a road straight down to the beach. It could be a problem getting such a large piece of equipment to the shoreline if there is no road access. It was too heavy and inefficient to fill the pool manually, because other methods are better.

It was a good idea to create the system a little way up from the water’s edge. In this method, it is the current in the stream that separates the pellets from other material. An attempt was made to hose the material at a boom barrier in the water, but this did not work well.

Figure 21. Pool for trapping pellets at Reier beach in Østfold.

A net was used to remove pellets from the pools. It could be an advantage to use nets with different mesh sizes. A sludge remover could also have been effective and small electric pumps could have been used to skim the surface. The disadvantage of such equipment is that it may involve problems and faults. If there is a large quantity of pellets, the Norwegian Coastal Administration's vacuum on a tractor could also work. This was not tested.

There could be a risk of falling into the pools and to make the job safer when removing pellets, platforms of planks were laid around the pools to stand on.

Figure 22. Removal of pellets using a net.

There needs to be a certain quantity of beach sand for this method to be appropriate and there must be a considerable amount of contamination. There are few beaches in Norway where this method can be used.

3.7 Tractor sieving

The tractor sieving consisted of a stone clearing machine that is used in agriculture. It had much too coarse gratings and too great a gap between them. The machine did not pick up the pellets, but instead dug them deeper into the other material. This method had previously been used effectively on other forms of plastic contamination. The method may have worked with a smaller gap between the gratings, but as it was attempted here it did not work.

Figure 23. Tractor sieving with equipment that had too great a gap between the gratings.

3.8 Machine tumbling

Machine tumbling is done using a drum in the excavator bucket. This is a method that works in oil countermeasures and it has been used for tumbling stones that have been contaminated with oil. For it to work with small pellets, a drum with a finer mesh was made. The method was not tried inn this response operation, due to trouble with the connections, so whether it works is uncertain, but it is assumed that there could be problems with it becoming clogged.

3.9 Other manual tools and methods

Sieves
Hand held sieves work when there are not very many pellets. They are easy to carry around and sieves with handles are easier to use. They must tolerate water, and metal is best because it can be shaped as needed. Equipment designed for children, such as blueberry pickers, can work for separating sand and pellets.

Figure 24. A modified bucket with a mesh can be used as a sieve.

Salad spinners
An attempt was made to use salad spinners, but stones got stuck so they did not work well.

Nets
Nets are used to remove pellets that are floating on the surface. There are many different kinds of nets and these are a very useful tool and were much used in the response operation. Some nets were made of a material that clung together, which made pellet removal difficult.

Spades with a metal mesh
There are also spades that have a metal mesh instead of a blade. The holes must not be too large. These could possibly be used to remove larger stones before sieving. This was not tested in this reponse operation.

Hand picking
Hand picking is possible but it is time consuming and not recommended.

Figure 25. Example of collection of pellets. This shows relatively clean pellets.

3.10 General information about the clean-up and protective equipment

The clean-up work occurred in vulnerable areas, such as protected areas, bird sanctuaries and national parks, and it was important that the people and the equipment caused as little damage or disturbance to flora and fauna as possible. The choice of procedure, equipment and method is therefore important.

Regardless of the working method, it is sensible to think about quantity and the capacity of equipment. The quantity of material taken up must be adapted to what the equipment can handle. This will prevent wear to the equipment, make the work less physically hard and make it easier to separate out organic matter and put it back.

During the response operation, some detection ampoules were found on the shoreline, so unidentified items must not be vacuumed up.

In this report, the focus is on experiences of different methods for removing pellets. There is no detailed discussion of health and safety aspects in this report. What protective equipment is to be used must be assessed in every case and work stresses must be considered.

Generally speaking, there is some equipment that makes a lot of noise and hearing protection should be used. There are also methods that will generate a lot of swirling particles, which may include small glass fragments, and protective eyewear must be used here. Protective clothing is also important, since sharp objects could pierce or graze the skin. Enough to drink, gloves, sun cream etc. are important to consider.

In uneven terrain, work should be dome in pairs so that one could raise the alarm in the event of fall accidents, bone fractures etc. There should also be a supervisor who knows where everyone is at any given time.

4 Shoreline types and clean-up methods

4.1 Cliffs and rocks

Generally speaking, few pellets are found in such steep areas as they have a tendency to be blown away. Pellets can lie in cracks or other places where they become trapped. Pellets can be effectively removed with vacuum equipment in such areas. Vacuum equipment used should have a nozzle that is flexible and can get into fissures and cracks for the most efficient clean-up.

4.2 Bedrock outcrops

Generally speaking there are few pellets on exposed smooth rocks. Leaf vacuums and vacuum cleaners work on smooth rocks. A trowel can be used to collect pellets that are lying in cracks. Pellets may come to rest in pools, where they can be taken up with a net. Pellets that come to rest in vegetation can be removed by pouring on water, so that they float. Where pellets are mixed into green algae such as ulva intestinalis it is best if this is dried before collection.

Figure *26*. *Pellets in green algae*

4.3 Boulders and stones

This shoreline type consists of boulders and stones larger than 60 cm. Both vacuum cleaning and leaf vacuums work here. Crowbars were used to lift the stones so that the pellets became accessible for vacuuming. Portable pressure washers were used to flush pellets out. There can be a large deposit of pellets on shoreline of this type. These are not always easy to detect. The pellets will lie well hidden under several layers of stone, which must be moved in order to find them.

4.4 Jetties and embankments

If jetties are made of stone material, high-pressure hosing may work, followed by booms and nets. It can be useful to have crowbars. Areas of stone material can hide plastic pellets and be difficult to clean up. Remobilisation of pellets can occur, especially in more exposed areas. Vacuuming can be used on jetties and in fissures.

4.5 Stones and coarse gravel

Relatively few pellets were recorded on shorelines with a stone size of 6-60 cm. If there is a belt of vegetation away from the waterline, there are often pellets there. It was found that pellets can be 5-6 cm down in the material. Vacuum cleaners and leaf vacuums work for collection. The stones must be moved around, which makes for demanding working conditions.

4.6 Gravel

Vacuum cleaners can be used on gravel shorelines, 2 mm - 6 cm. Some gravel will also be picked up and the material can then be sieved. The vacuum can be turned on and off so as to avoid picking up too much gravel. In these cases not all the gravel will make it into the bag, but will fall out again. Exactly what works must be found by trial and error. Leaf vacuums can also work well in dry conditions and can also work satisfactorily in wet conditions.

4.7 Fine and coarse sand

Sieving and water baths work well on contaminated sandy beaches with sand grains of 2 mm and below. On loose sand, sieving is best. If the sand was closely compacted before the pellets came, they will be lying on top and vacuum cleaners can be used. Dry sand is the easiest to work with.

Figure 27. Pellets typically lie in the belt of vegetation and often at both ends of the beach.

4.8 Silt and clay

This is a compacted surface, more so than a sandy beach. Suction of some kind will often work here. Where pellets are lying on top, a vacuum cleaner can be used. There is little energy in such areas and only the tides will move the pellets. It can often be a logistical challenge to get to these areas.

4.9 Peat, coastal meadow and wetland areas

These are difficult areas to clean up. It is important here to get started early, before the pellets are covered by vegetation. There is relatively little remobilisation if the pellets are covered by vegetation. If the underlying surface is hard, vacuuming will work. These areas can be worked on in winter if conditions are dry.

4.10 Summary of clean-up methods and shoreline types

Table 1: Clean-up methods by shoreline type.

Shoreline type/ method	Cliffs and rocks	Bedrock out-crops	Boulders and stones	Jetties etc.	Stones and coarse gravel (6-60cm)	Gravel (2mm-6cm)	Fine and coarse sand (0.063-2mm)	Silt or clay (< 0.063)	Peat, coastal meadow and wetland areas
Sieving	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Suitable	Possible	Unsuitable
Vacuum cleaner/leaf vacuum	Suitable	Suitable	Suitable	Suitable	Suitable	Possible	Possible	Possible	Suitable
Suction vehicle with hoses	Suitable	Suitable	Suitable	Suitable	Suitable	Possible	Possible	Suitable	Suitable
Excavator with water bath	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Suitable	Suitable	Unsuitable	Unsuitable
Hand picking	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable

(red)	Unsuitable method
(green)	Suitable method
(yellow)	Possible method

The clean-up method is determined by the surface. If it is hard rock and large stones, vacuuming is most relevant and if it is soft sand, sieving is often the optimum method. With hard compacted sand, vacuuming pellets is also possible, but with soft sand many other things will be vacuumed up at the same time. Cleaning up pellets is normally best in dry conditions, when the methods work much better.
Hand picking is regarded as an unsuitable method, since it is inefficient.

5 Clean-up level

It is difficult to be exact about clean-up levels and final criteria. How good is “good enough” depends on a number of factors and often on who is doing the inspection. It will not be possible to remove all pellets. The level of clean-up will depend on the starting point, so photographic documentation during the work is important. The clean-up level depends on what it is possible to collect and there should be a cost-benefit assessment.

The clean-up level will also depend on the area that is contaminated. If there are many areas in a bird sanctuary area, it is important to clean up very well, because it is thought that birds could mistake pellets for food. A high level of cleanliness is expected in outdoor recreational areas, on bathing beaches etc. Logistics and accessibility are also important factors. The situation will decide how much is collected and what clean-up level can be considered as good enough.

It is very important to prioritise the areas that can benefit most from the clean-up. The rule of thumb that was used in this response operation was that if no more than ½ litre of clean pellets was the result per person per day, the clean-up work was stopped. In areas with a lot of pellets, a great deal more is often collected, which is why it is important to prioritise these areas.

Figure 28. Collection of pellets with only a few pellets among the material.

6 Identification of plastic pellets and environmental surveys

During the first phase, the focus was on finding the source and the first analyses were performed by Norner on behalf of the Oslofjord Recreational Outdoor Council. The type of plastic and the area of application of the plastic pellets were identified. The plastic was for use in the manufacture of unpressurised pipes, extruded sheets and mouldings. These facts were important for finding the source.

It also emerged that the police took a sample from a container that was leaking when the ship Trans Carrier called at Tananger near Stavanger. Taking samples in the field was handled by Norwegian Nature Inspectorate (Statens naturoppsyn), Inter-municipal committes againt acute pollution (IUA) and the Norwegian Coastal Administration. This was done to connect the samples from the field with the source. The samples were analysed by SINTEF. A geographical spread was chosen for sampling. A sample from Sweden was also analysed. Analysis confirmed that finds in the field were from Trans Carrier, and that the pollution was spread to the areas where deposits were recorded. Analysis also showed that other plastic pellets from other sources were also found. These often have different colours.

Figure 29. Overview of where the samples that were analysed were taken.

SINTEF has issued the following two reports:

1. Identification and characterisation of plastic pellets. Analysis of source material. Report OC2020 A -072
2. Identification of plastic pellets in connection with the Trans Carrier incident. Comparison of samples from the field and the source sample. Report OC2020 A-103

In the first report, the plastic pellets were analysed for polymer type and it was found that the pellets consist of isotactic polypropylene. The content of inorganic elements, organic chemicals and organic compounds was analysed. The content of UV stabilisers and softeners proved to be low to undetectable. No flame retardants were found.

In report two from SINTEF, nine field samples were analysed to see if they could be connected with the source sample. This was determined with the aid of comparison of chromatography, mass aspects and diagnostic ratios. Seven of the samples corresponded to the source sample, while two did not. The sample from Frierfjorden in Telemark was not from Trans Carrier; it looked different and analysis showed that it had a different origin. The test from Østfold that was not from the source either also had a different appearance. This shows that there is also other contamination/plastic pellets in nature that is not from Trans Carrier.

The source sample has a characteristic shape that is easily recognisable. Those cleaned up in the field are round pellets of 2-3 mm in diameter, pressed in on each side.

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Figure 30. Round pellets of 2-3 mm in diameter.

Environmental surveys were also performed on birds and fish. Eider ducks were investigated by the Norwegian Institute for Nature Research (NINA) to see if plastic pellets had been ingested. 50 birds were examined. It was concluded that there had been little ingestion of plastic pellets by eider ducks and there is no connection with the increased winter mortality rate among eider ducks in the outer Oslo Fjord in spring 2020.

The Institute of Marine Research investigated the stomach contents of fish fry and coastal fish species from the area identified as most affected by the plastic pellet spillage. 633 individuals of nine fish species were collected along the coast of Østfold. The testing was performed as part of the Institute of Marine Research's shoreline note series. All the individual fish were examined and no plastics were found in any of them. It was therefore concluded that the spillage had not affected the fish species investigated in the affected area.

7 Map solution

The Oslofjord Recreational Outdoor Council (OF) set up the first public solution for registration of finds at the end of March 2020. A better solution was subsequently developed in collaboration with the municipality of Fredrikstad. This was a map solution in which the general public and others involved could register deposits of pellets. After this became a national response operation the Norwegian Coastal Administration developed its own solution for registration of plastic pellets, which is based on an existing shoreline app in the Norwegian Coastal Administration's map solution (Kystinfo). This also gives the opportunity to automatically obtain statistics. Kystinfo shows the status of the areas with regard to inspections, clean-up work and quantity of plastic pellets collected. Established users could also now use the Norwegian Coastal Administration's Strand-APP for registration of finds and their status and to upload pictures etc. Information from the Fredrikstad solution was transferred to Kystinfo.

Experience from users shows that there is a user threshold for use of Kystinfo, but once it has been learned the solution works very well. It is an advantage to limit the number of users who enter data. This is about quality assurance that what is entered is correct with regard to position, quantity collected etc. It is important that positions of inspections and plastic finds are entered correctly as this makes work easier for those who go out to do the clean-up work later.

The Norwegian Coastal Administration also developed a public solution, similar to the Fredrikstad/OF solution, which was read-only. This is simplified in respect of categories for the inspection and status phases. It was found to be positive and more user friendly to show the status during the response operation.

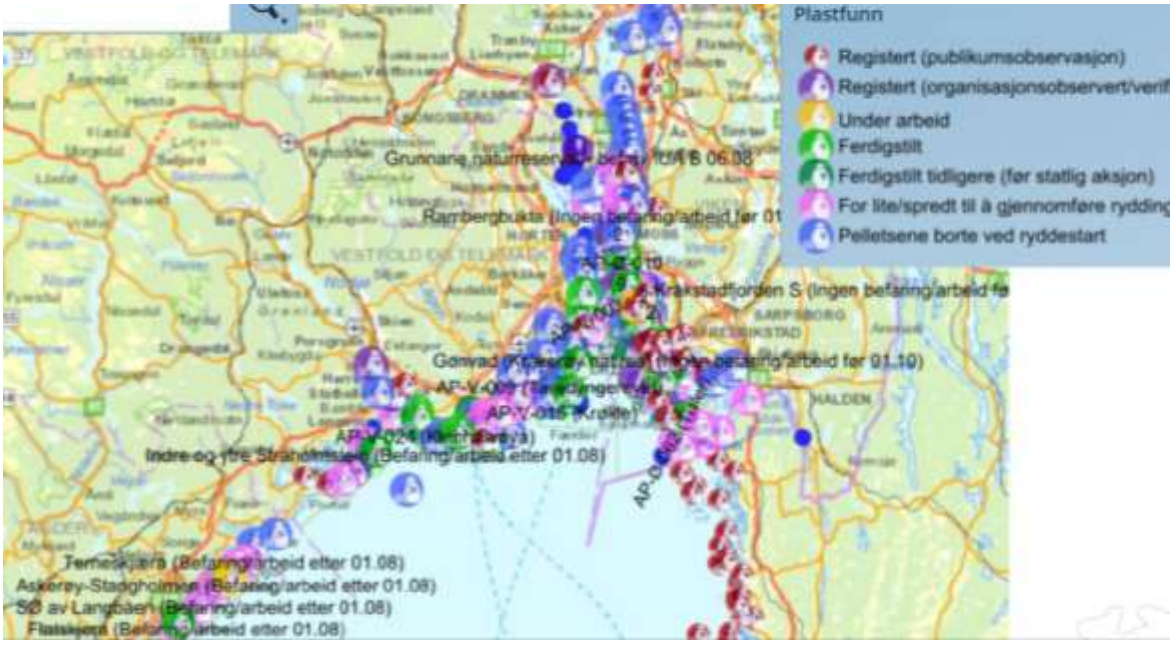


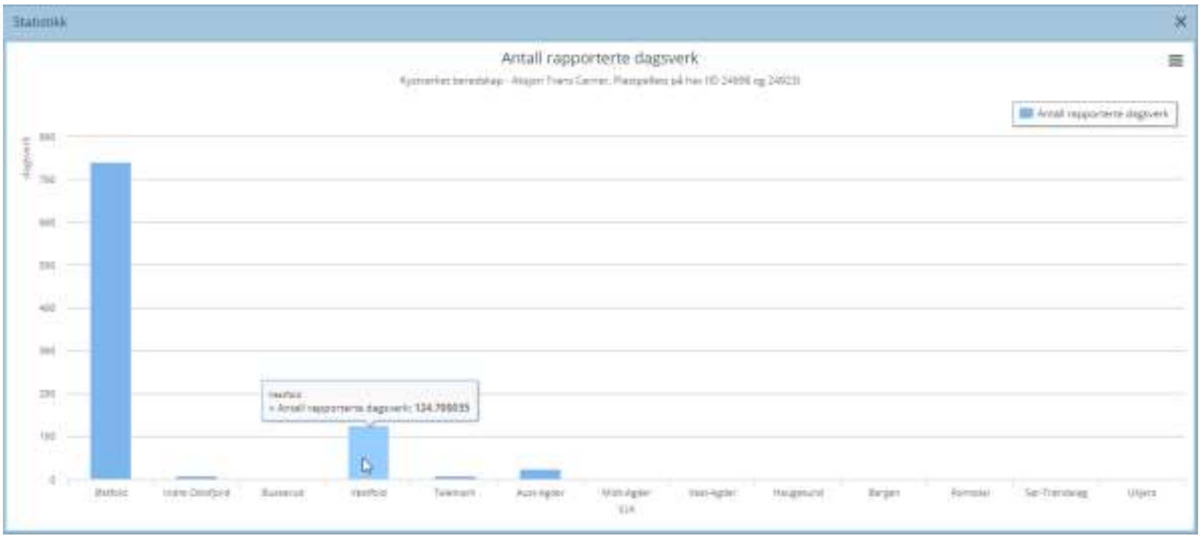
Figure 31. Registration in the Norwegian Coastal Administration's map solution and progress of the inspection and clean-up work.

Figure 32. Zoomed in on the map solution; blue shows inspections. For more informa

Figure 33. The Norwegian Coastal Administration's Strand-APP

Table 2: Report taken from Kystinfo, showing the number of registered finds by work status. The different colours show the progress in work, e.g green colour indicates cleaning completed.

Table 3: Report from Kystinfo, showing the number of reported man-days per IUA.



8 Pellet accounting

In the response operation an estimate was made of the quantity of clean plastic pellets that was collected, including what was collected before this became a national resonse operation. In the field the quantity of pellets collected was estimated in litres. Litres were preferred because it was felt to be easier to estimate in litres than in kilos in the field. The conversion factor from litres to kilos is known. Based on the total collection quantity, the percentage of pellets was estimated.

Updated quantities of clean pellets are entered in Kystinfo. These figures are updated as work proceeds in the different positions.

What was picked up privately has been entered into the accounting if this is known by the Oslofjord Recreational Outdoor Council or the Norwegian Coastal Administration. It can be expected that collection from private jetties and shorelines occurred to a greater extent that is unknown. This means that the pellet accounting can be underestimated somewhat.

There have been considerable deposits of plastic pellets in Sweden, but at the time of writing the quantity they have collected is unknown.

In the first phase of the response operation the figures in the pellet accounting were taken from reports submitted, but as all collection figures were entered in Kystinfo, figures were taken directly from the map. The solution of taking figures from the map is straightforward and suitable for purpose.

Estimating the quantities collected in the field has been done as precisely as possible, but is based on assessment and estimate. Estimating the percentage of pellets in collected material cannot be done completely accurately, but it is considered to be good enough and appropriate for this incident. Otherwise all pellets would have to be separated out from other waste. The Norwegian Coastal Administration believes that the method chosen covers the purpose.

What was collected was sent as “residual waste” and was not sorted further. This was considered suitable since the quantities collected were limited.

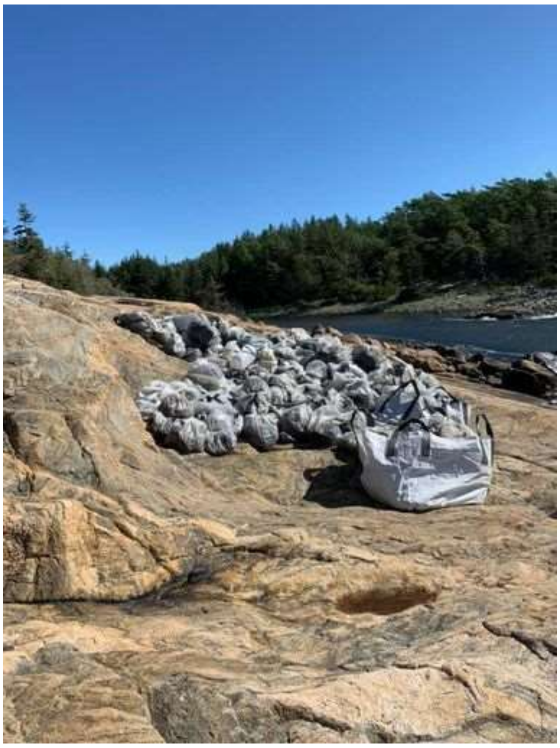
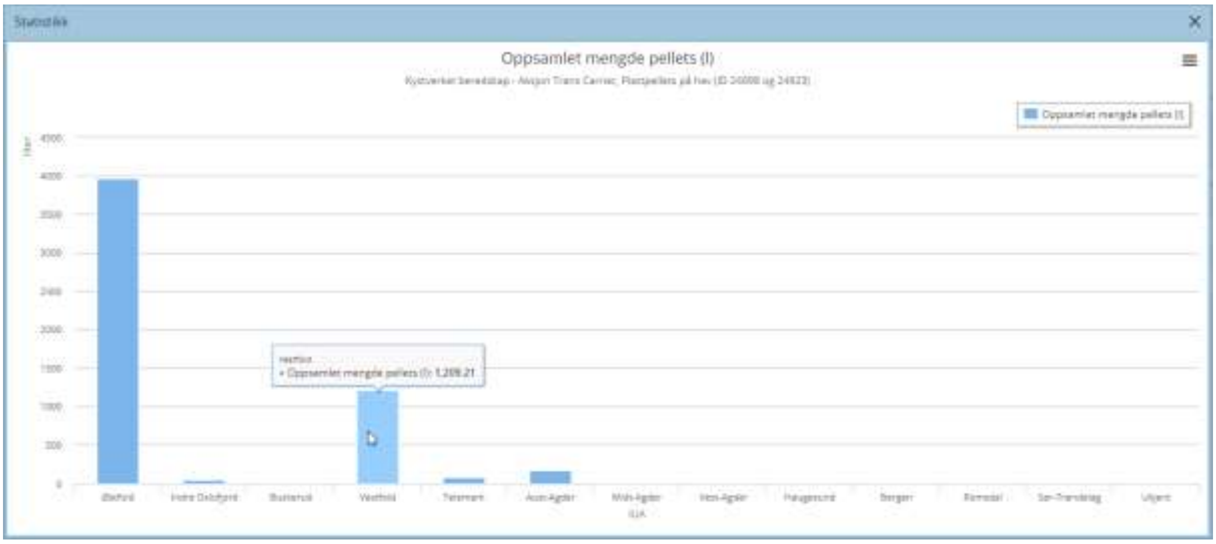


Figure 34. Collected waste.

Of the 13.2 tonnes of pellets spilled, about 4.4 tonnes of clean plastic pellets have been collected in Norway. (The number is updated in June 2021.)

Table 4: Report from Kystinfo, showing the quantity of pellets collected per IUA.



9 Other experiences

A technical group was established consisting of shipowners, insurance, the Norwegian Coastal Administration, Inter-municipal committes againt acute pollution and the Oslofjord Recreational Outdoor Council. Regular meetings were held. ITOPF has experience of pellet response operation and it was useful to hear their experience. They also attended the meetings. It is important to discuss different methods and to share experiences. It is especially important to obtain the experiences of those who have done the clean-up in the field at these meetings, so that experiences are known and shared within the group. The videos and photographs that were taken are the best way of presenting and explaining the methods.

In autumn 2020, we gathered together physical representatives of all those who had been involved in the clean-up work. This was a very useful day at which we discussed and collected experiences.

Training films were made in the use of equipment and these were shared at meetings of the technical group. Films were also made of maps and the strand-APP, which were shared in various ways, including via Google Photo, which made it easy to share with individual users via SMS text.

10 Summary

Clean-up of plastic pellets is certainly possible, but is time consuming and extensive. In incidents with this volume of spillage, a long drawn-out clean-up operation can be expected. This is especially because of remobilisation and new deposits from the sea. Pellets break down very slowly compared with oil, so there will be no self-cleaning effect.

Good inspections followed by a rapid clean-up are important. If the opportunity and the equipment exist, smaller finds should be dealt with at the time of inspection, to reduce the probability of remobilisation. Good map systems in which finds, photographs, material collected etc. can be entered are essential for maintaining an overview in a respons operation; colour codes for finds were used that indicated progress of the clean-up work.

Work must be prioritised in the areas where considerable quantities of pellets have been recorded. There is considerable remobilisation on hard surfaces. It was found in the response operation that some cleaned-up areas had new deposits from the sea.

It is especially important to start the clean-up as quickly as possible before pellets can be spread to new, more extensive areas. Where there are large collections of pellets, suction vehicles and effective measures should be put in quickly. It is also crucial to the result that there is knowledge of the methods and tools when the response operation starts, so that there can be efficient collection where there are large concentrations of pellets. It is also important to hold regular meetings where the different stakeholders such as shipowners, insurance, Inter-municipal committes againt acute pollution (IUA), the Norwegian Coastal Administration and others can share their knowledge of methods and experiences along the way.

All the material collected from the clean-up response operation was delivered as “residual waste” (normally what is left after other fractions have been sorted out).

A cost-benefit assessment is essential for the clean-up work. It was mainly vacuum cleaners, leaf vacuums and sieving that were used. These are simple methods that worked satisfactorily. For effective work in the field, it is important to have spare parts to hand so that equipment can be repaired on the spot. In the field, many tools must be taken along to ensure robustness in the collection.

The clean-up work can be monotonous and cause repetitive strain issues.

On one shoreline, an excavator and water baths were used for pellet removal. If this type of mechanical equipment can be used, efficiency is considerably increased, but in this incident there were few shorelines where this was possible.

It is important to try out new methods and to think about technological developments and especially the machines and equipment that can be used. Successful and effective collection demands practical thinking, creative problem solving and imagination.

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