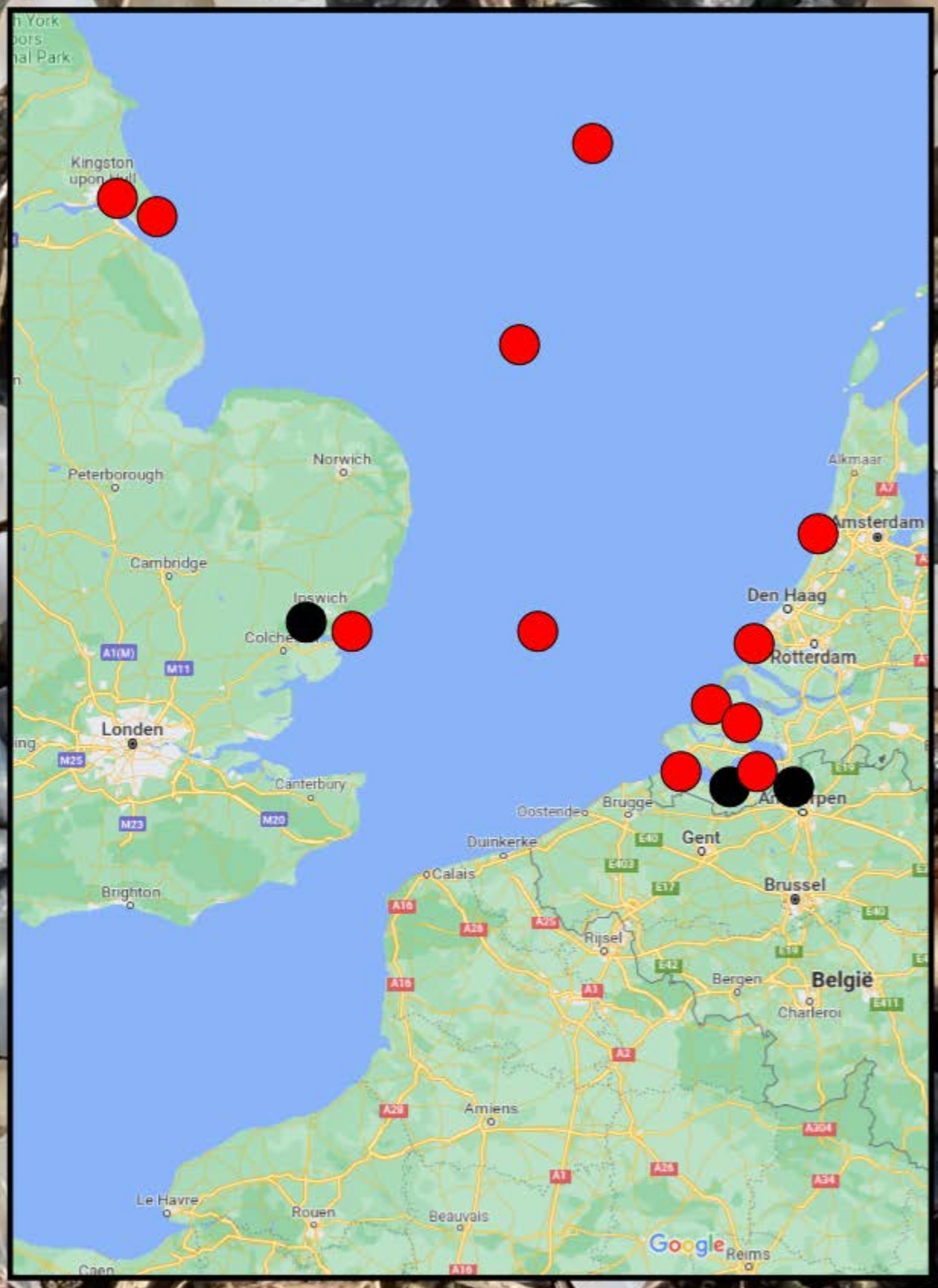
Westerschelde: plastic nurdles

Sources, transport, deposits



Westerschelde: plastic nurdles

Sources, transport, deposits
Autumn 2021
A.A.

Content

Preface

There's a lot of plastic on the banks of the rivers Rijn and Maas in the Netherlands. When I started an exploration around Rotterdam some years ago, I met people in the field that showed me that there was more to be seen than meets the eye on first glance: nurdles.

Having seen millions of them and their sources a conflicting image arises: nurdles cause irreversible damage to nature and form a technically easy-to-solve problem.

Having saved some free time on my job I decided to spend 3 months of a sabbatical on the subject. The goal is to analyse the problem, to increase awareness and speed up the solution.

Introduction

The Westerschelde is a challenging water body for analysing the spreading of plastic nurdles because they are found in various places and originate from several sources. When looking more closely to deposits, wind, water system and sources it is possible to track back part of the nurdles to their origin and tell the story of their floating journey.
Floating journey means that this research is limited to floating plastic and does not look into what happens under water or in the sediment.

As to the origin (the source) of the nurdles, the assumption is that the Westerschelde can be divided into 4 sections:
I Terneuzen, middle
II Antwerpen/Schelde east
III North Sea, west
IV Kanaal Gent-Terneuzen

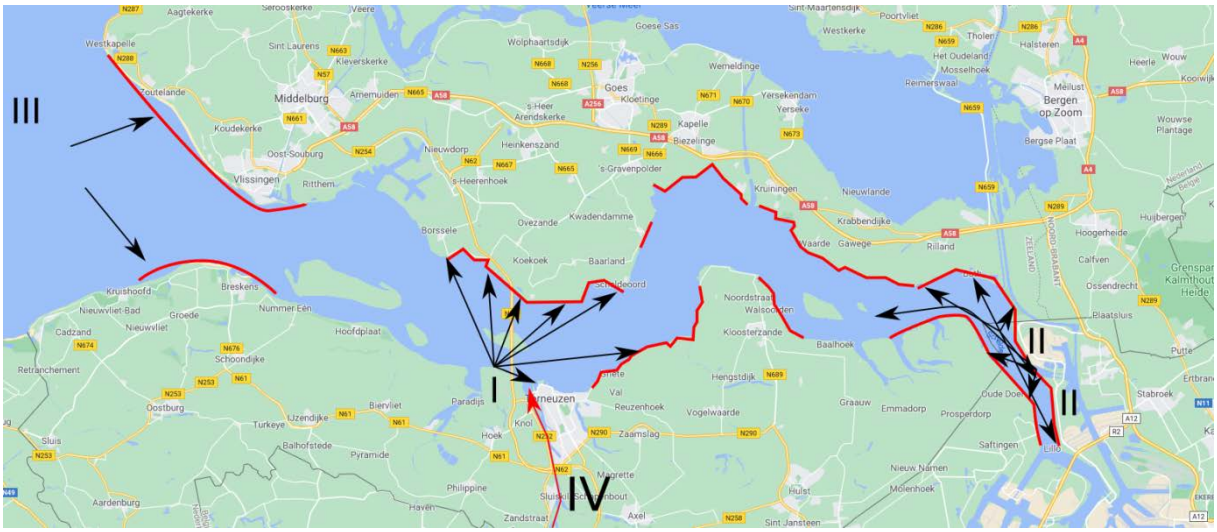


Illustration 1-1: four nurdle subareas in the Westerschelde

1. Terneuzen

1.1 Source

1.1.1 PE and PP

According to the web site of DOW https://nl.dow.com/nl-nl/locations/terneuzen.html it produces LDPE (since 1966) and LLDPE (since 1982) in Terneuzen. Even though propylene is made as a raw material it is transported by pipeline to other locations (Antwerpen, Rotterdam) and not used in Terneuzen for nurdle production.
This division of production in PE-nurdles and PP-nurdles is confirmed in a study of TNO on decarbonisation options for the nurdle industry in the Netherlands in which DOW took part (lit 1).

1.1.2 Sewage system and overflow

Because of safety precautions and to avoid damage, industrial sites are drained to avoid flooding after rainfall. The sewage system which is designed to do this job can accommodate rainfall up to a certain maximum. In more extreme cases the system will overflow in a controlled way.
In the Netherlands this applies roughly for a rain shower that occurs once a year.

Given the sewage system and the overflow there are a few possibilities for a leaking route:
1. The system is always leaking because it does not function as it should;
2. The system leaks by overflow.
In both cases another condition should also be met: nurdles are spilled onto the production floor of the site. With rain, or when cleaning, they end up in the sewage system.

Ad 1
Because of aging/subsidence of the system its filters might not work properly. Furthermore the changes above ground in the installations might not have been followed by corresponding standards below ground. The DOW-site is several decades old.
Ad 2
This is always the case. But if the nurdles accumulate at certain places because they float, they might flow over with the excess of drainage water.

After the discharge into the Westerschelde, current (tide) and wind start transporting the nurdles.

1.2 Transport

Hereafter the principle of the transport of the nurdles in the Westerschelde is described. In Annex I assumptions and methods are discussed in more detail.

1.2.1 Model

To do the calculations a simple model was used that roughly follows the current directions in the Westerschelde (black lines and angles in figure 3).

1.2.2 Current

For the floating velocity the (half hourly) values at the height of Terneuzen were used from the Scalwest2000 model (lit 2).

1.2.3 Prevailing winds

Prevailing winds in the Netherlands are from the south west. Roughly 60% of the windrose surface lies between south and west.

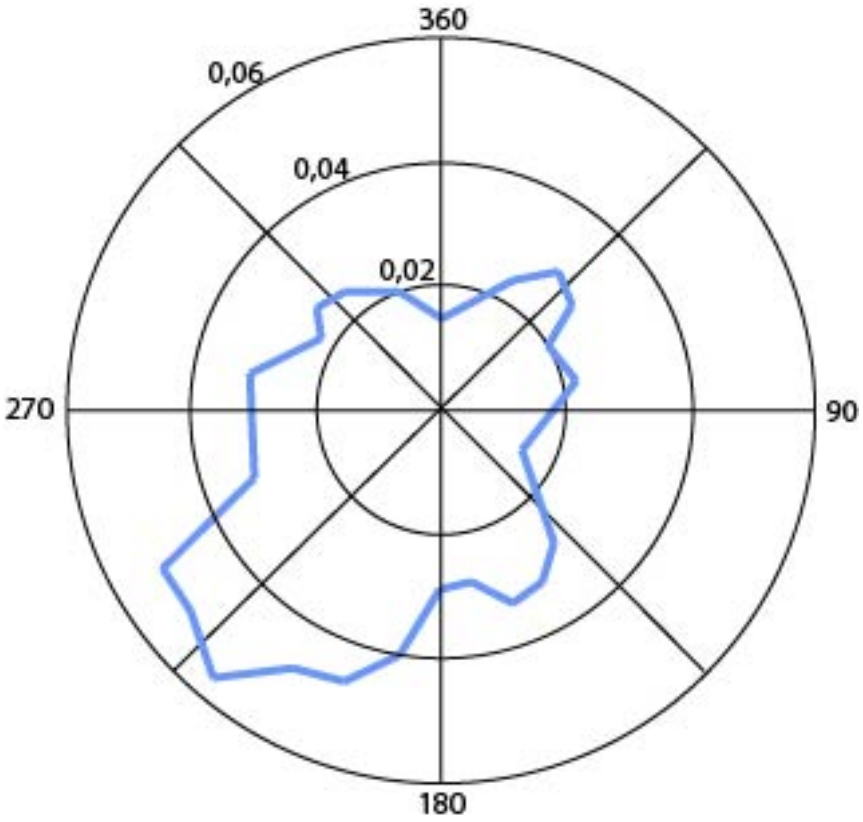


Illustration 1-2: Windrose De Bilt (The Netherlands) 21st century

1.2.4 Wind force converted into floating speed

It is furthermore assumed that the floating speed is about 5% of the wind force. This factor is derived from research on surface transport of oil in which conversion of wind into floating should be from 2.5 to 4 percent. https://www.ncbi.nlm.nih.gov/books/NBK220700/.

Because oil is a coherent liquid with a certain viscosity it is likely that individual plastic nurdles that are also lighter will float somewhat faster (assumption 5 %).

This assumption could rather easily be measured by dumping a few cubic metres of small floating material, for example duckweed (kroos), into the water on a south bank and determine the floating speed with a canoe or a drone.

1.2.5 Rain

Furthermore it is assumed that the nurdles are leaking with heavy rainfall (assumption 2). So for the period of 1970-2020 all the daily sums bigger than 30 mm (54) were extracted from the data of the meteorological station of Terneuzen. These are daily data which means that they don't show the exact moment of the rainshowers. However if one looks at the wind data for these particular days, this moment can be set at the hour when the wind velocity rises (indication that the depression front passes).

Because the wind data of Terneuzen are not publicly available, the hourly data of the meteorological station of Vlissingen were used.

1.2.6 Weather patterns

The weather in summer when raining, in general follows the same pattern. There are a few warm days and then a depression passes by from the southwest (16 of 24), often with thunder. 7 of these summer showers came in from the northwest and 1 from the northeast. In autumn the picture is more diverse with 8 showers from the southwest, 9 from the northwest and 1 from the northeast. In total: south-west 31, north-west 18, northeast 5. There were no showers from the southeast.

All this information is publicly available except for the model? Scalwest2000?
But it is also possible to get the online current from the Rijkswaterstaat/KNMI Harmoniemodel: https://waterkaart.net/gids/stroomatlas-noordzee.php?p=knopen#over-deze-stroomatlas.

1.2.7 Tide

The leaking period/moments (with heavy rainfall) and the tide are separate events. This means that the leaking period can occur during the whole tide-cycle. There was no access to historical tide information so the calculations were done for the whole tide-cycle to see where the nurdles can end up. (By decomposing in factors the x- and y-distance can be calculated and placed in a coordinate system).
The origin (0,0) is chosen on the emission point of the DOW-site in the Westerschelde.
The above data lead to a flow pattern given in figure 3.

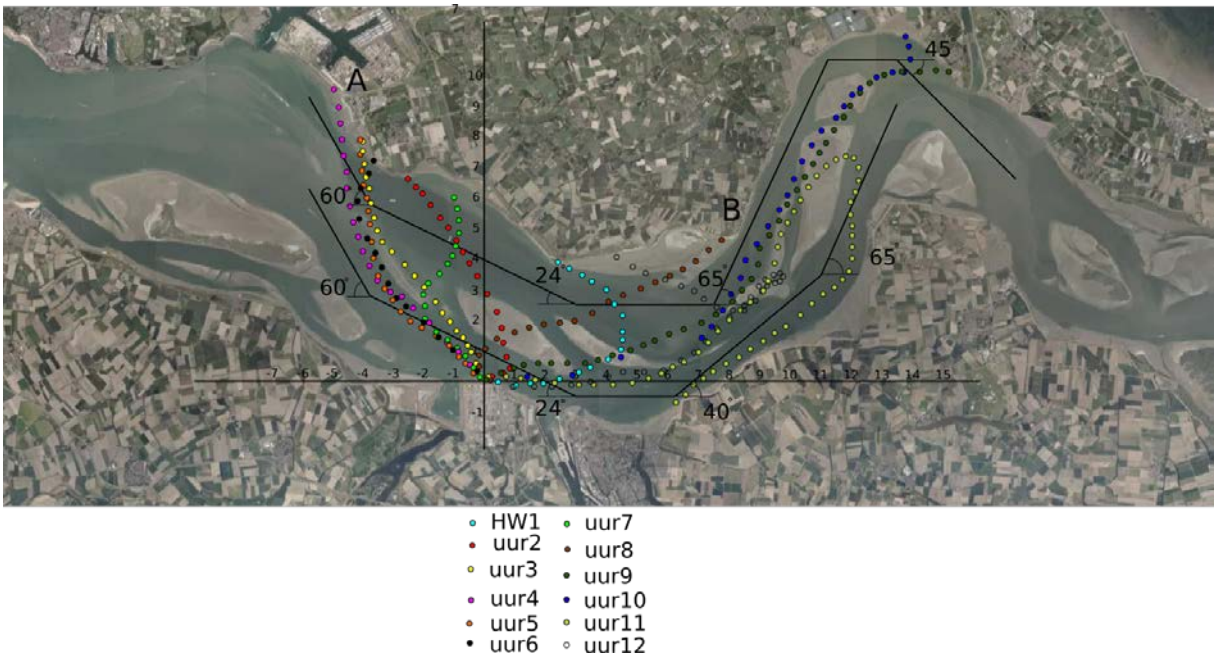


Illustration 1-3: Calculated flow paths of nurdles after a rainshower on 28-7-2013 for an average tide cycle.

Because about half of the heavy rainshowers come with southwestern winds the nurdles that leaked from the sewage system float to the north bank of the Westerschelde. In the example 75% of them wash up on the stretch between the harbour Vlissingen-Oost (A) and Scheldeoord (B).

Once washed ashore they tend to stay in place. This is because waves (from ships as well as from wind push them in the direction of the bank. Spring tide doesn't change this picture because the water level rises only a few dm: the nurdles are pushed somewhat further ashore.
Only when the water rises significantly because a storm starts blowing from the north-west the nurdles can start to move and float back to the south bank. Because with the storm the water is pushed into the constriction between the UK and the Netherlands and pushes into the Westerschelde the west-east current is dominant. All of the sandbanks are also flooded.
After the nurdles crossed the Westerschelde in the reversed way they will accumulate in favourable places like corners of stone protected banks, coves and inlets (see Annex II).

Assumption 1
If nurdles would leak continuously they will spread out in a pattern that looks like the mirror image of the windrose. This image will stretch to the east and west along the direction of the tide current. The nurdles will then end up somewhere on a bank (Illustration 1-4).

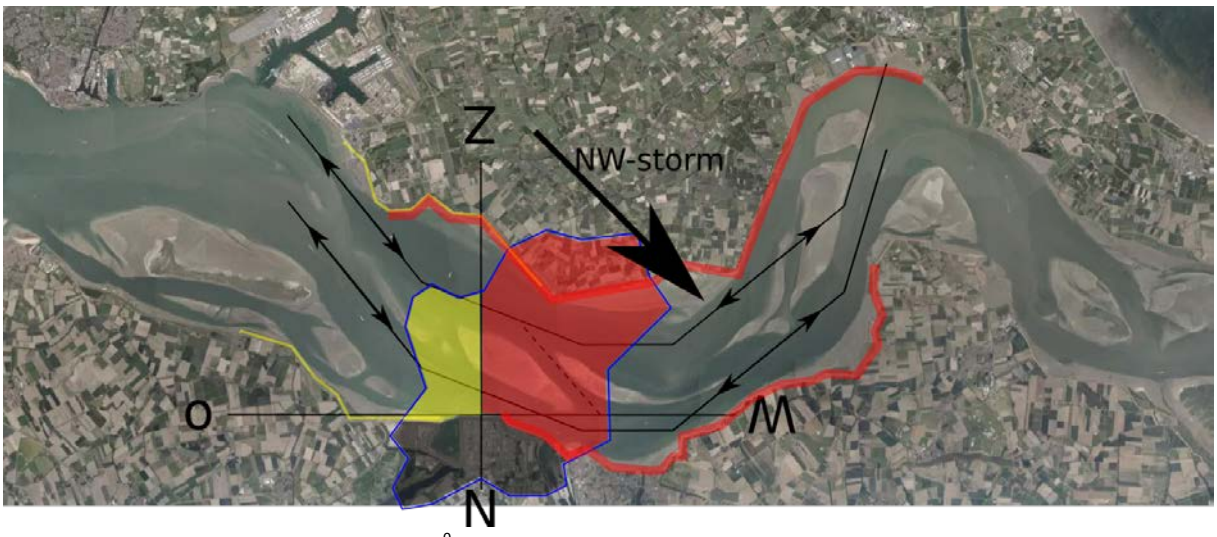


Illustration 1-4: Windrose is rotated over 180^0(mirror image); red are westerly winds, yellow are easterly winds grey are northerly winds

It must be possible to simulate this process for the whole meteorological (wind) history in combination with the astronomical tide on the map of the Westerschelde .In this simulation the spread will be bigger than in the pure combination of the windrose and tide data because wind shifts are also taken into account.
This simulation can approach reality closer if one could also take into account how north westerly storms cause part of the nurdles to cross over from the north to the south bank.

1.2.8 Rainshowers, season, wind direction, wash up stretch

In figure 1-3 the current trajectories for every half hour are given for the rainshower of 28th of July 2013. A comparison can be made by taking the wind vector (wind direction and speed multiplied by time) of all 54 rain showers > 30 mm (1970-2020). This gives a point cloud (illustration 1-5).

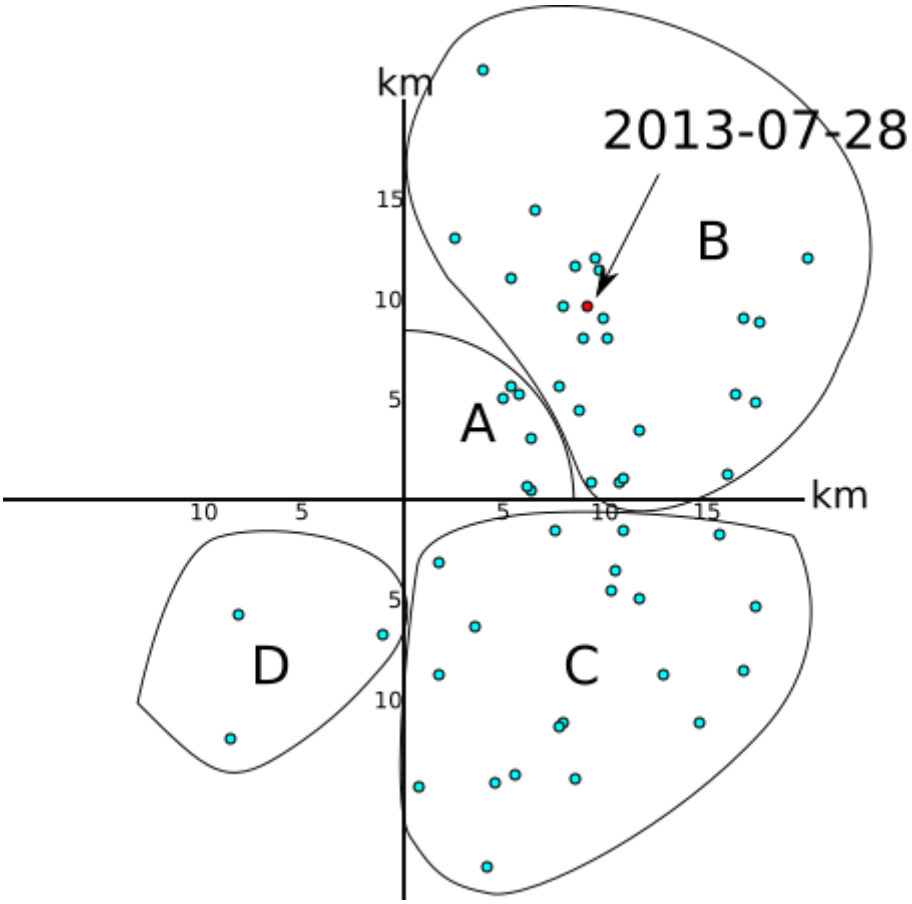


Illustration 1-5: wind vectors of 54 rainshowers > 30 mm (1970-2020)

The flow path of nurdles that leaked in section B of the figure will roughly look like the ones given in figure 3; the ones in section C (north western winds) will not cross the water but will wash ashore directly somewhere east of Terneuzen. If the wind blows from the north(east) the nurdles will wash back ashore immediately after they were launched.
If the wind is not strong enough to let the nurdles cross the Westerschelde they will go to and fro with the tide until they end up on a bank. Because the prevailing wind is from the southwest most of them end in section B and wash ashore in the stretch AB (illustration 1-3).
With this model and assumptions it is not clear what happens to the 10 11 hours and western section winds (dark green and dark blue).

1.2.9 Sand banks

If the nurdles leak into the Westerschelde during lower tide they might end up on one of the sand banks. In the Scalwest model this possibility can be derived by combining the flow paths with the lower half of the tide and the rise and fall of the sand banks (Middelplaten and Rug van Baarland). Only on hours 8 (brown path in figure 3)) and 9 (green path) nurdles can strand temporarily on the Middelplaten. On hour 10 (blue path) they can strand on the Rug van Baarland.
When the water level rises again 8 and 9 will end up somewhere at point B (Scheldeoord) and 10 somewhere at Hansweert (prevailing wind is from the southwest).

1.2.10 Transport along the bank

Transport along the banks plays an important role in the distribution of nurdles in the Westerschelde. Traditionally a lot of banks are protected with smooth stone claddings. If the wind comes in at an angle a current develops that, in combination with the waves, starts transporting floating material. If the wind is strong enough, it also starts transporting sediment and shells and stones.

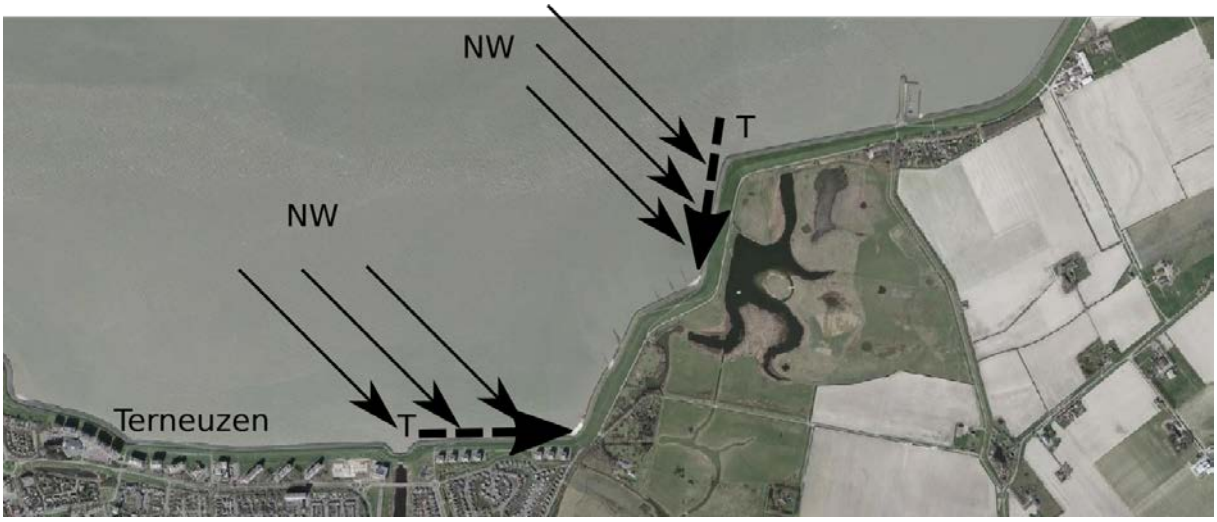


Illustration 1-6: White shell beaches developed due to Northwest storms and transport (T) along the stone banks.

This transport is strongest with northwest storms because both the wind force and the water levels are the highest.
The transported rubble, among which a lot of organic debris, then accumulates in favourable corners. Because there's a lot of shells and sand in the transport stream these corners are recognizable as sandy to white triangles.

That this physical process is of a considerable strength is shown in the picture below. The (black) debris lines show that when the beach hampers the transport process, the water level decreases about 1 to 2 meters and part of the transported media are deposited.

Illustration 1-7: Debris lines at Breskens: a volunteer is gathering nurdles where the line ‘goes down’.

Illustration 1-8: Shell beach at Terneuzen: one of the deposits of nurdles

This phenomenon occurs on the south as well as on the north bank because the width of the Westerschelde is up to 5 km (strijklengte). Especially with south westerly, westerly and north

westerly winds the swell (deining) is quite strong. The force on the south bank will be some bigger because wind force and water levels with north westerly storms are higher.

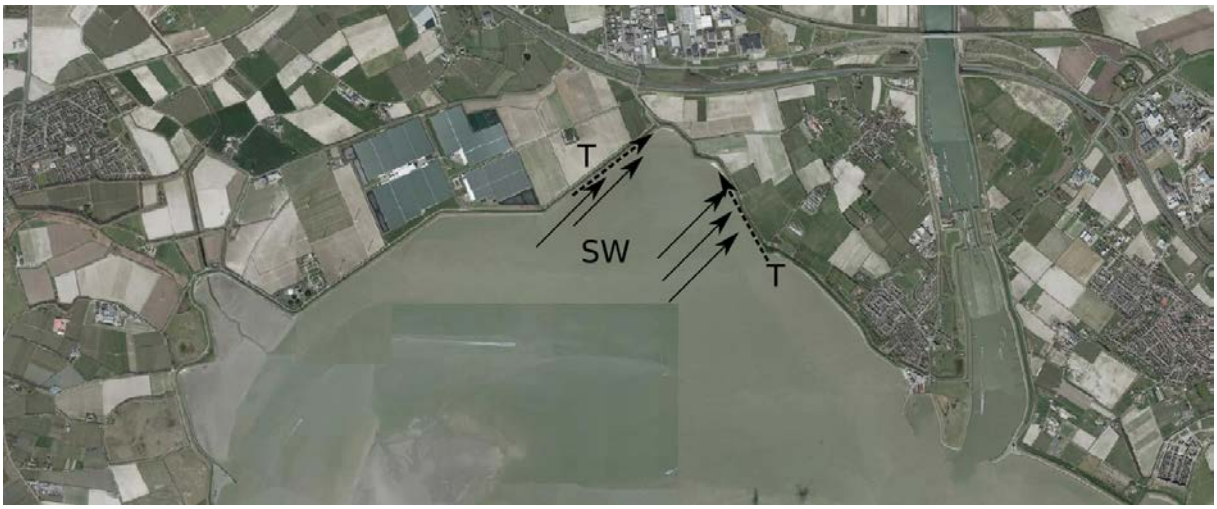


Illustration 1-9: Bank transport (T) with southwest winds on the North bank at Bath

1.2.10.1 Veerhaven- Perkpolder-Walsoorden

A special case of bank transport takes place on the east bank that runs from Veerhaven to Walsoorden. Even though one expects that the nurdles will leave the bank with the northwest storm they follow another path.
After entering the Veerhaven and leaving on the other side with high water, a part of them end up in the Perkpolder and a part follows the bank and end up in the harbour of Walsoorden.
This process in which storm, current, underpressure, ship waves, the outside bend and probably shoaling play a role is described in Annex III.

The Perkpolder used to be an agricultural polder. It was reconnected to the Westerschelde in October 2015. This means that the nurdles that stranded there did so in 6 years time.

1.3 Deposits

Illustration 1-10 shows the visited locations with an estimation of the number of nurdles found there.

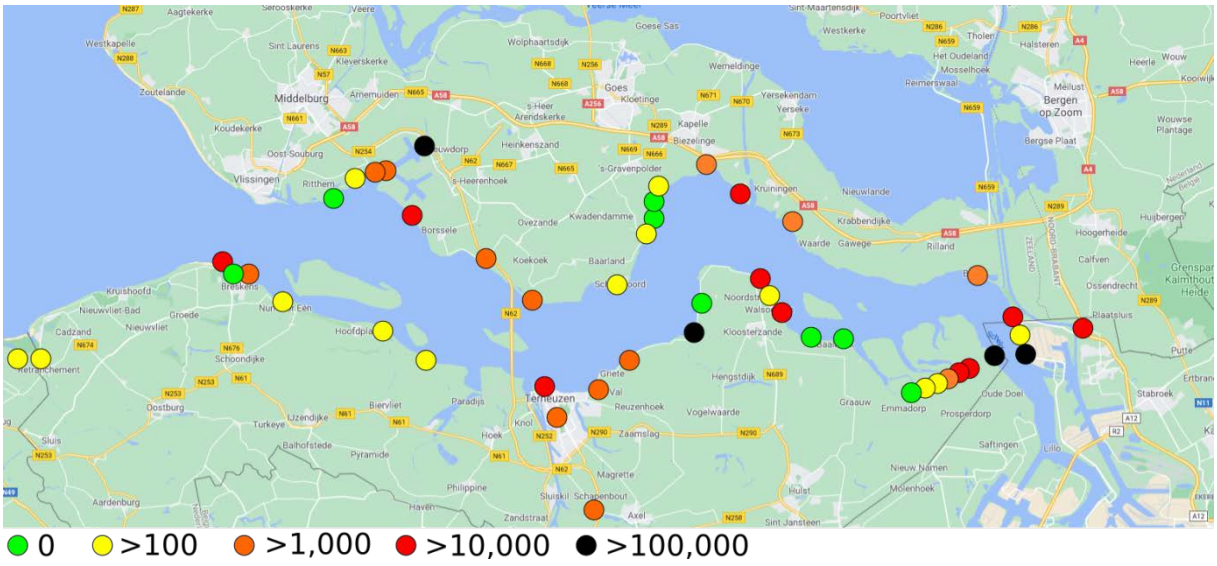


Illustration 1-10: deposits Westerschelde

During the field visits an estimation was made of the number of nurdles visible per m^1 and the length of the stretch where they were found in those numbers.
By multiplying a rough indication is given of the total amount of nurdles on the surface at that location. This gives an indication of the gravity of the plastic pollution on that spot. Especially on the locations where there is a lot of organic debris the total numbers are several times higher because a part of the nurdles is invisible.

1.4 Conclusions

According to the model a large part of the nurdles that washed up on the south bank east of Terneuzen originate from DOW-chemical. This calculated proof can be made stronger by testing which part of the nurdles is LDPE and LLDPE.
This study can be made more exact by using the 10 minute-data of the station of Terneuzen (not publicly available) in combination with the latest hydraulic model for the Westerschelde.

The two most important mechanisms that cause the spreading of the nurdles are: normal feed by prevailing south west winds (to the north bank), occasional shifts driven by north west storms (from north bank to the south bank).

This has been going on for decades so a charged system has developed with stocks of nurdles in favourable places. It depends on the orientation and form of the bank (sharpness of the corner) whether the nurdles end up there forever or will stay there until the next storm will force them to cross over and end up on the south bank.

2. Antwerpen

Introduction

Concentration in this research is on the nurdles that reach the Westerschelde so the attention is focussed on the area around the first sluices in the mouth of the Schelde (Zandvliet/ Berendrecht). The mechanisms that apply for DOW at Terneuzen also yield for Antwerpen. Furthermore the inside of the port itself forms a source by leaking through its sluices.

2.1 Sources

In the port of Antwerpen nurdles are made and distributed by several producers (among other: BASF, INEOS, Covestro, Lanxess, Total, Borealis Kallo, left bank). They work together with companies in the logistic sector that take care of handling and transport for example Katoen Natie.

The majority is located on the right (east) bank of the Schelde and have the drainage of their production sites on the inside of the port in the 'Kanaaldoks' and 'Havendoks'.
These direct individual sources are not analysed. The consequence of leaking inside the port is that the sluices Berendrecht and Zandvliet become an indirect source (see 2.2.2).
The same applies probably for the Boudewijnsluis, Kallosluis and Kieldrechtsluis. If nurdles are leaked here, it is assumed on the basis of the calculations, that they will not reach the Westerschelde and end up on the banks of the Schelde in Antwerpen.

2.2 Transport

To calculate the pattern of nurdles in the mouth of de Schelde use was made of two mechanisms: rain and sluice. With rain the mechanism is largely similar to the one in Terneuzen. Because nurdles can also reach de Schelde through the sluices and will then follow another route, this mechanism is described separately (2.2.2)

2.2.1 Rain

Hereafter the principle of the transport of the nurdles as a consequence of rain showers in the mouth of de Schelde is described. It is very similar to the situation at Terneuzen. In Annex I assumptions and methods are discussed in more detail.

2.1.1.1 Model

To do the calculations a simple model was used that roughly follows the current directions in the Westerschelde (black lines and angles in figure 2.1).

2.2.1.2 Current

For the floating velocity the (half hourly) values at the height of the BASF site in the harbour were used from the Scalwest2000 model (lit 2).

2.2.1.3 Rain

Furthermore it is assumed that the nurdles are leaking with heavy rainfall. So for the period of 1970-2020 all the daily sums bigger than 30 mm (54) were extracted from the data of the meteorological station of Terneuzen. These are daily data which means that they don't show the exact moment of the rain showers. However if one looks at the wind data for these particular days, this moment can be set at the hour when the wind velocity rises (indication that the depression front passes). Because the wind data of Antwerpen look a lot like those of Vlissingen, the hourly data of the meteorological station of Vlissingen were used.

2.2.1.4 Weather patterns

The weather in summer when raining, in general follows the same pattern. There's a few warm days and then a depression passes by from the southwest (16 of 24) often with thunder. 7 of these summer showers came in from the northwest and 1 from the northeast. In autumn the picture is more diverse with 8 showers from the southwest, 9 from the northwest and 1 from the northeast. In total: south-west 31, north-west 18, northeast 5. There were no showers from the southeast.

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2.2.1.5 Tide

The leaking period/moments (with heavy rainfall) and the tide are separate events. This means that the leaking period can occur during the whole tide-cycle. There was no access to historical tide information so the calculations were done for the whole tide-cycle to see where the nurdles can end up.
(By decomposing in factors the x- and y-distance can be calculated and placed in a coordinate system).
The origin (0,0) is chosen on the border of Belgium and the Netherlands between BASF and het Verdonken Land van Saeftinghe. This is also the emission point of the water purification plant of BASF.
The above data lead to a flow pattern given in illustration 2-1.

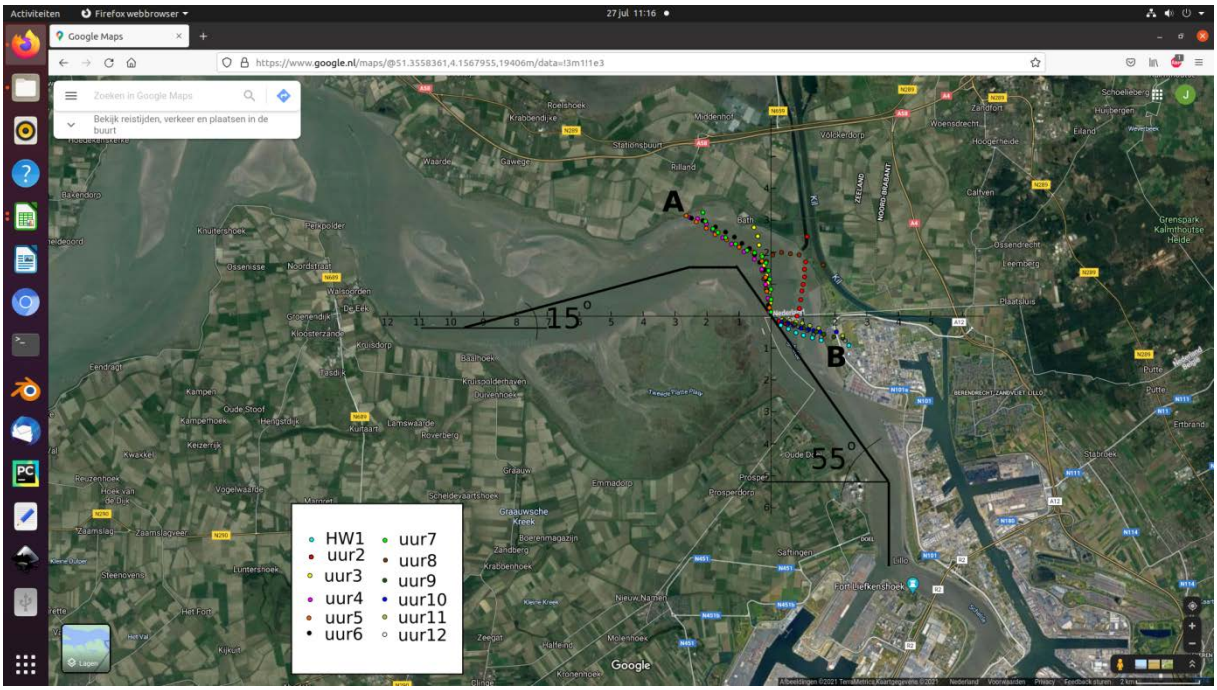


Illustration 2-1: Calculated flow paths of nurdles after a rain shower on 28-7-2013 for an average tide cycle.

Because this part of the Schelde/Westerschelde is orientated south-east to north-west all nurdles that should leak from the origin will end up on the east bank on the stretch AB in the figure 2-1. About 44 of the other rain showers (54, figure 4)) will have the same effect on the nurdles leaked: they will wash up somewhere on the east bank close to the stretch AB.
Only 10 showers (section D and 7 wind vectors at the left side of section C in figure 1- 4) will probably have for effect that the nurdles strand on the west bank (Verdronken Land van Saeftinghe)
Once washed ashore they tend to stay in place. This is because waves (from ships as well as from wind push them in the direction of the bank. Spring tide doesn't change this picture because the water level rises only a few dm more: the nurdles are pushed somewhat further ashore.
Only when the water rises significantly because a storm starts blowing from the north-west the nurdles start to move and float into favourable corners, inlets and coves.

An exact north west storm doesn't exist. The wind shifts depending on how and where the depression passes. This means that during high water levels the wind may also shift to a more westerly direction. Because this gives another interface of forces there will be some slightly deviant routes of nurdle transport. This might make nurdles travel more inland (to the east).

2.2.2 Sluice = source

If the nurdles are leaked on the inner side of the port they accumulate there. Because production of nurdles has been going on here for several decades, they will have spread over the whole port. This process could be simulated in a model taking into account the relevant parameters. The result will be a charged system in which shifts occur caused by, especially wind, and less by current because the water level of the port is held on a more or less constant level by the sluices.

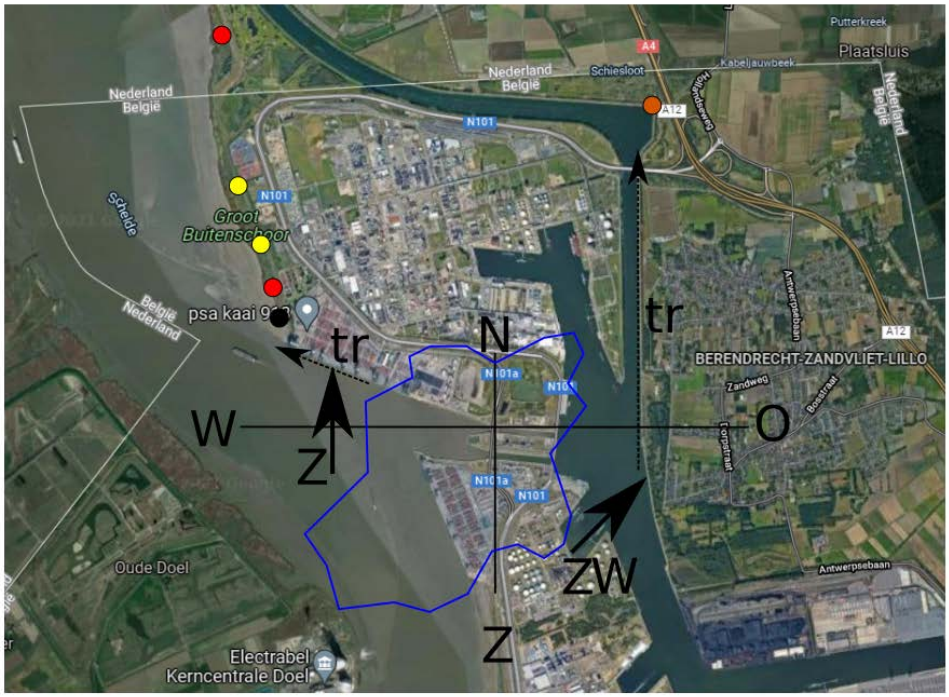


Illustration 2-2: Nurdle transport from sluices

Because of the prevailing wind directions, nurdles will accumulate in certain places but will not wash ashore because the level is held constant and most of the banks are quays and sheet piles.
A good example is the north east corner of the canal (orange dot) to where nurdles are transported (tr) with wind coming from the south west.
Pay attention to the fact that these nurdle masses/clouds are mobile and will float to where the wind takes them!
If one should want to catch the nurdles this is a very good location to do so. It is also relatively easy to scoop out those nurdle masses/clouds with a net.

Illustration 2-3: NE-corner Rijn-Scheldekanaal, in the background the BASF-site, black arrow pointing at the floating mass of nurdles

The target water level inside the port (on the east bank) is held at TAW + 4,17m with a variation of 0.6 around this average. The water level at Prosperpolder in the Schelde River (outside) is on average TAW +2,45 m (1991-2000). Nearly always the waterflow is from the inside to the outside (lit. 5).

Illustration 2-3a: in more detail

Illustration 2-3b: in more detail

Even though wind conditions are less favourable for pushing nurdles to the sluices (Zandvliet and Berendrecht), this will occur with wind coming from easterly directions (20-30% of the time). The nurdles are then ‘sluiced’ into the Schelde.

The illustration (2-2) shows that with westerly winds the orientation (WNW-ESE) of the PSA kaai 913 is not favourable for the nurdles to float to the river but they will not float back into the port either because of the higher water level inside and will keep floating around outside, close to the sluice and to the quay (of sheet piles).

When the wind turns for example to the south (Z) the nurdles will be transported (tr) to Groot Buitenschoor or with easterly winds to the other side (Verdronken land van Saeftinghe) and further into the Westerschelde. Prop water may also cause the nurdles to float to the river. The result nearby (Groot Buitenschoor) is shown in the illustration hereafter.

2.3 Deposits

2.3.1 East bank

Illustration 2-4: Nurdle deposits Groot Buitenschoor

After washing ashore somewhere on the outer bounds of the ‘Buitenschoor’ storms from the north west will transport them further into the reeds (yellow dots and reddish band) and into corners (red and black dots). On this bank there are several millions (see Annex VI).

Illustration 2-5: Nurdles in high concentrations over a distance of about 600 m (red arrows) where PSA-kaai 913 ends.

2.3.2 Verdronken Land van Saeftinge

With easterly winds nurdles are transported to the west bank of the Schelde and further into the Westerschelde. In Annex IVA the results for the calculations of wind from the north, north east, east and south east are illustrated.

This spreading of nurdles is schematized in the illustration hereafter (2-6) by the red arrows and the storm (black arrows) which pushes the nurdles into the Verdronken Land van Saeftinghe and into the Groot Buitenschoor.

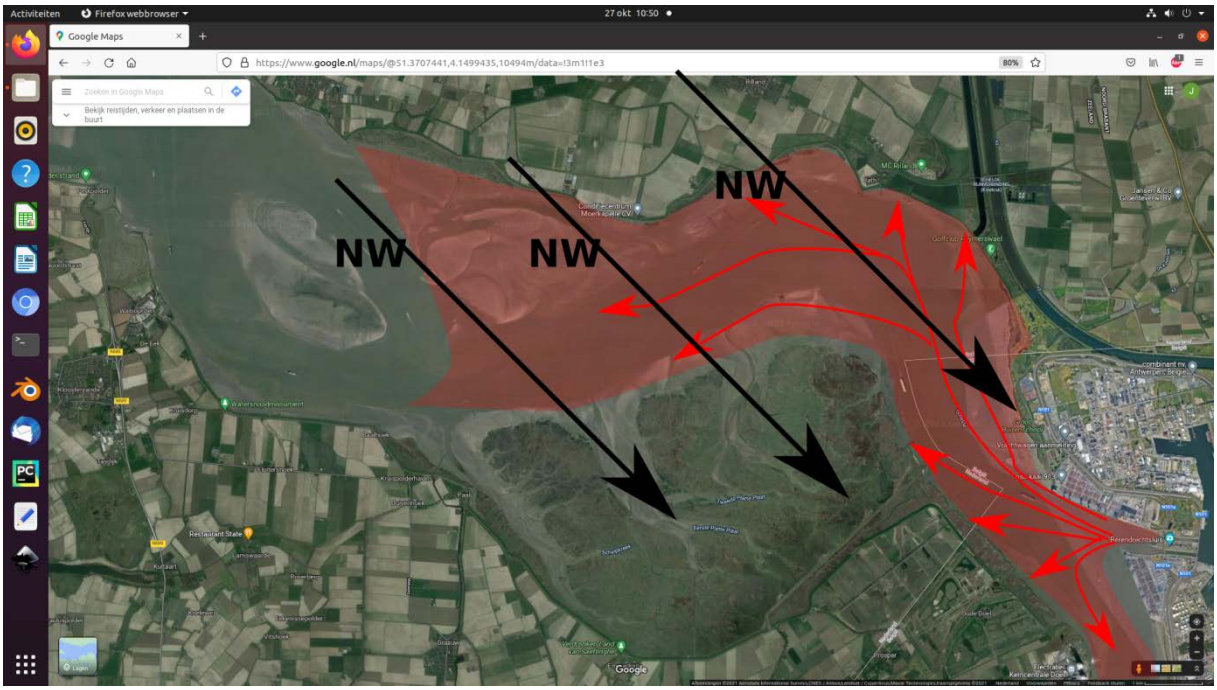


Illustration 2-6

This ongoing process has led to the deposits as illustrated on the following map (data are given in detail in Annex IV B).

Illustration 2-7: Number of nurdles increases towards the east

In Annex IVB the ABCDE deposits (Illustration 2-7) are illustrated more closely. It is shown that the nurdles follow about the same path as the organic debris does. The gullies also play a role in this process. The number of nurdles increases towards deposit E.

2.3.3 West Bank, deposit F and Hedwigepolder

Even though it looks like deposit F belongs to this increasing order, it doesn't. The nurdles for A, B,C, D and E were deposited indirectly after a storm. The ones in F washed up directly from the sluice source by the wind and tide (current).
The deposits ABCDE and F are hydraulically separated by a dike (green line in the illustration 2-8).

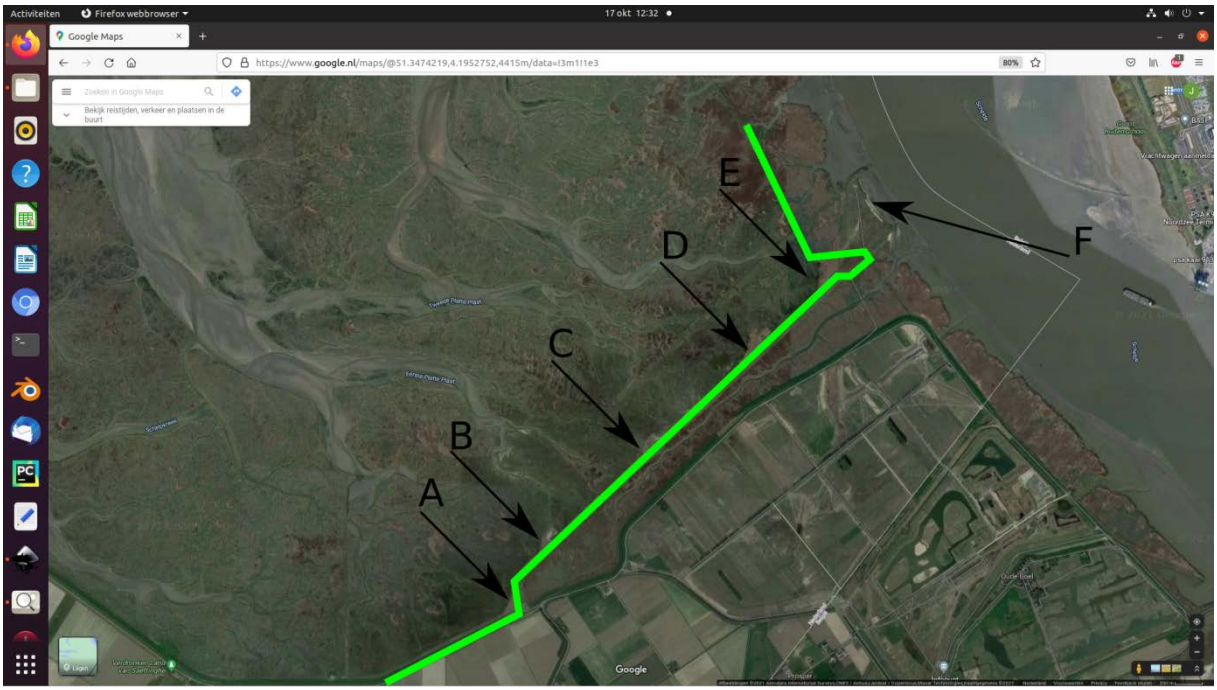


Illustration 2-8

The deposits in F are high (Annex IV). This means that the whole stretch of the west bank here will have about these concentrations of nurdles.

Illustration 2-9: Deposits in F in detail

Since 2020 De Hedwigepolder is under construction. This polder will be reconnected to the (Wester)schelde as a nature compensation for the further degradation of tidal nature on the banks of the Westerschelde.
Ports are often situated in estuaries where the river meets the sea. It is only with a lot of human wisdom that these opposing interests are translated into reasonable compromises.

In de Hedwigepolder a system of gullies is dug to maximize the surface of tidal nature. This way the water of the Schelde can penetrate deeply into the former polder.
Because the nurdle concentrations along the west bank here are as high as in deposit F, it is likely that it will take only a few years before the nurdles will have spread over this system of gullies in considerable concentrations. This symptom could be treated by catching them on the surface in the inlet with some sort of installation. It is much more effective however to close the leaks.

Illustration 2-10: De Hedwigepolder under construction. In the background the sluices Zandvliet and Berendrecht. (Foto: provincie Zeeland https://www.zeeland.nl/natuur-en-landschap/natuurpakket-westerschelde/hedwige-prosperproject)

3. Sources North Sea UK

Introduction

The assumption is that nurdles found in the westerly part of the Westerschelde float in from the North Sea after they were spilled at production plants on the east coast of the UK.

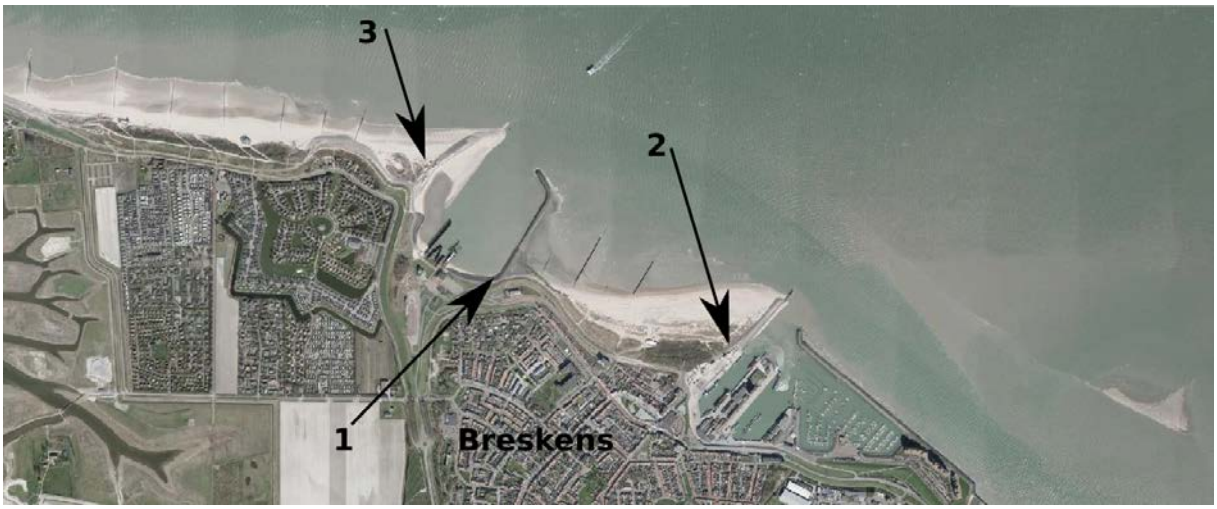
3.1 Transport

Transport occurs when meteorological conditions combine with geographically favourite orientation of the port/ estuary system.

With north-westerly storms a lot of the surface water of the North Sea is blown into the constriction between UK and the Netherlands (whip up).

These storms cause elevated water levels in Belgium, the Netherlands, Germany and in the south-east of UK. This NW-direction is recognizable in the pattern of locations where considerable numbers of nurdles (thousands) are found in the Westerschelde (deposits Roompotstrand, gemaal Campen, Hansweert, Groot Buitenschoor and Verdronken Land van Saeftinghe).
They tend to accumulate in southeast corners and are always found close to the highest waterline

NW-wind engenders transport (T) along east-west orientated banks



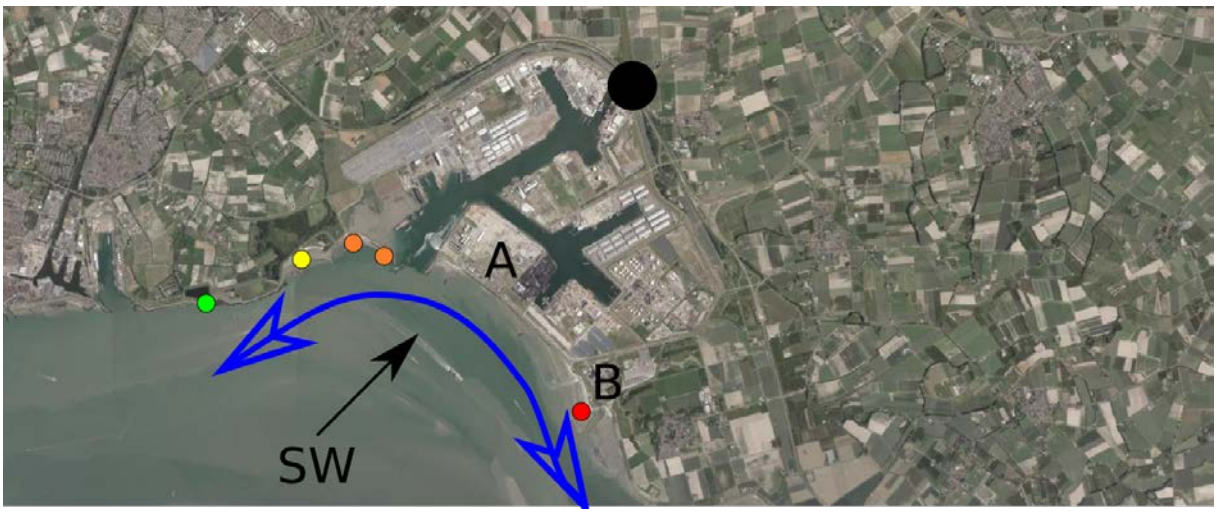
SE-corners

Interesting about the findings (see Annex V) are the Bio Beads on the beaches of Breskens and the wheelshaped bio medium (1) in the Zwin. These objects are used in waste water treatment in the UK (lit 4 Wallerstein). Every now and then large spillings occur of these media (see 3.2.1).

When the storm passes, the direction of the wind in general changes to west and then south-west which is the prevailing direction in the whole Canal-region. Nurdles that still float around wash ashore somewhere on a north bank. Part of them accumulate in places where circumstances are favourable like inlets and coves.

3.1.1 Vlissingen

The deposits around Vlissingen look like the ones found somewhat further on the north bank of the Westerschelde. The hot spot (1,000,000) in the port cannot be explained with nurdles floating in from the North Sea. The source must be inside the port. As a special case this has been worked out in Annex VI.



Because of the deep tidal gully, also used as the main shipping route, the tidal current (blue arrow) is high (up to 1.5 m/s) in this bend, pushing the water towards the bank. With the prevailing wind nurdles are deposited on the north bank. The source must be the North Sea because on the sea side of the bend the numbers are modest (yellow, orange) and towards the end they increase (orange, red) through prevailing wind.

3.2 Deposits and sources

3.2.1 Case Bio Beads Ipswich-Rotterdam

Contents

Bio Beads/black nurdles Ipswich>Rotterdam

13-9-2021

Introduction

On the 28th of March 2019 thousands of black nurdles washed up on the beaches of Zuid-Holland in the Netherlands. There were several articles in the press on the subject (examples in Annex 1). The stretch where the bio beads washed up was roughly from Rotterdam to The Hague (25 km).
It is estimated that the volume that washed up on the beaches was about 5 m^3 meters. 1 litre on every 50 m.
Hereafter this event is reconstructed. With data from wind and current and a primitive model the nurdles (bio beads) are tracked back in time to the estuary of Orwell and Stour.

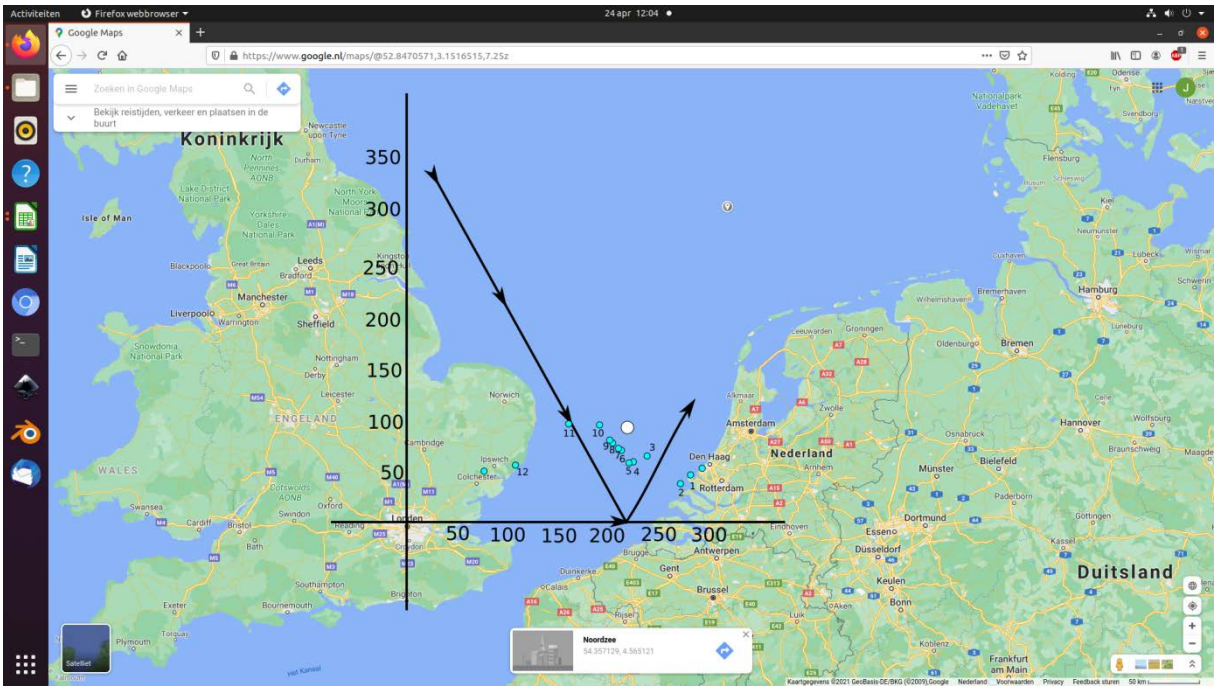
Bio beads/ black nurdles on the beach of Zuid-Holland

Bio Beads are 3 to 6 mm’s in size.

To check the assumption that the Bio Bead leakage could have taken place in Ipswich a field visit was conducted on the 9th of September 2021: thousands of Bio Beads were found along river Orwell.

Model and assumptions

To do the calculations a simple model was used.



Even though the tides come and go and the current direction will turn around every 6 hours, there is a remaining result (rest stream) in the North Sea because of its geography and relative shallowness. The current is downwards along the coast of the UK and goes up again at the height of the narrowing of the Channel near London. It then follows the coast of Holland, Germany and Denmark and flows back into the ocean just off Norway.
https://www.sciencedirect.com/science/article/pii/S0078323411500193

It is assumed that the direction of the current has a 60^0 angle with the x-axis and the point where the current changes from downward to upward is under the amphidromic point (white dot). (By decomposing in factors the x- and y-distance can be calculated and placed in a coordinate system). The assumption for the rest stream is 0.1 m/s (premise considered as reasonable, by the author, in relation to current velocities in the North Sea).
For the wind the hourly data of the meteorological station at Hoek van Holland were used.

It is furthermore assumed that the function that expresses the floating speed as a result of the wind force is not linear for nurdles. The hypothesis is that they cling together with the foam on the waves and therefore travel at the top. According to the Beaufort scale the first caps on the waves develop with a wind force of 5 and foam starts to fly with a force of 7. So from a force of 5 they are floating faster and from a force of 7 they start to fly-jump. Therefore up to Bft 5 the conversion factor is set at 5% up to Bft 7 it is 10 % and above it rises to 25%. (By decomposing in factors the x- and y-distance can be calculated and placed in a coordinate system).
The assumption that under Bft 5 the conversion factor is 5% is derived from research on surface transport of oil in which conversion of wind into floating should be from 2.5 to 4 percent.
https://www.ncbi.nlm.nih.gov/books/NBK220700/.
Because oil is a coherent liquid with a certain viscosity it is likely that plastic nurdles will float somewhat faster (assumption 5 %).

After tracking back for 12 days (blue dots) the coast of UK is reached at the height of Ipswich

Probable cause and probable source

These nurdles (black, and bigger than 3 mm) are used as Bio Beads in waste water treatment. There are several examples of them leaking to rivers during heavy rainfall. (lit 1).

12 days before the 28th of March (= the 16th) heavy rain brought flooding to parts of England and Wales.
http://floodlist.com/europe/united-kingdom/rivers-overflow-england-wales-march-2019

There's of course several uncertainties (model, rest stream, floating behaviour nurdles) which would lead to a large spread (hundreds of km's: London to Hull?) if all taken into account in the calculations. However, in this case, the moment of heavy rainfall and the tracking-back-wash-up-moment coincide which justifies a closer look at the Stour and Orwell estuary.

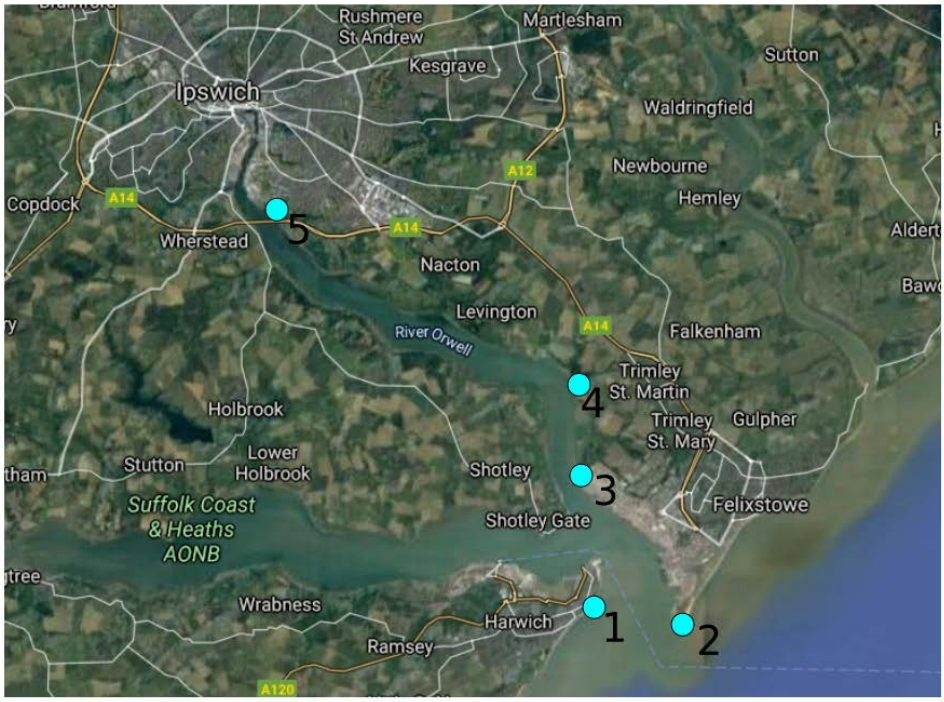
A few kilometres downstream from Ipswich the waste water treatment plant of Anglian Water has its point of discharge in the middle of Orwell River which makes it assumable that leaked Bio Beads can reach the North Sea.

If so these Bio Beads must also have washed up on the banks of river Orwell. Finding them is not easy. But it must be possible if they are really there.
It is not easy because of their size (small), colour (small black particles blend into their surroundings because organic particles/debris is also often blackish), distribution (it is 2 years ago and storms/high

water levels and high tides have distributed the Bio Beads further and vegetation on the banks hampers the search.
However, knowing that they gather up where the prevailing (storm) winds in combination with high water levels take them, Dutch experience learns that there is a reasonable chance to find them in the north east and/or south east corners (Prevailing winds in the Netherlands and England are very similar). These corners are often the same spots where a lot of (general/normal) plastic washes up and are therefore often known to local volunteers cleaning them up every now and then. Because the Bio Beads/nurdles are small they are often overlooked. Because they are light and small they are always at the highest high water line.
Looking at the Orwell estuary a few probable locations were selected.

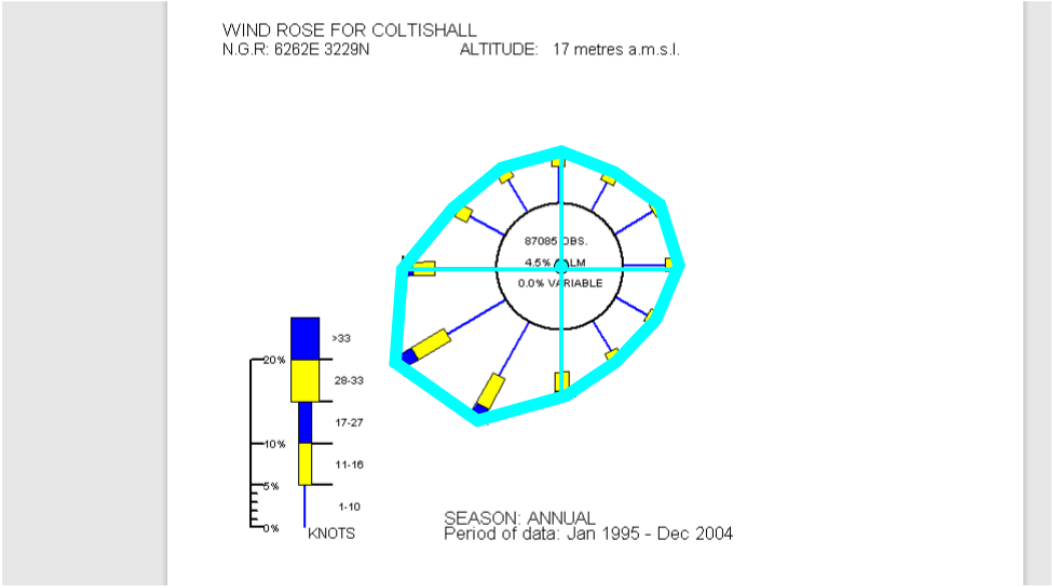
Field visit river Orwell 10-9-2021

Certainty can't be given by a calculation and communication is a little difficult with a subject scientifically les known. Therefore it was decided to conduct a field visit. The COVID-virus didn't cooperate so the research was reframed into a quick scan of one day: 5 locations were visited. (More detailed information on the nurdles found is given in Annex II).



This choice was made because leaking of BIO Beads was assumed on location 5 and the prevailing winds are from the south west

On the metoffice the (10 year) wind rose is given for Coltishall (close to Norwich).
eastern-england_-climate---met-office.pdf (metoffice.gov.uk)



Wind rose Coltishal: the blue line is a schematisation of the picture and used in the transport analysis hereafter

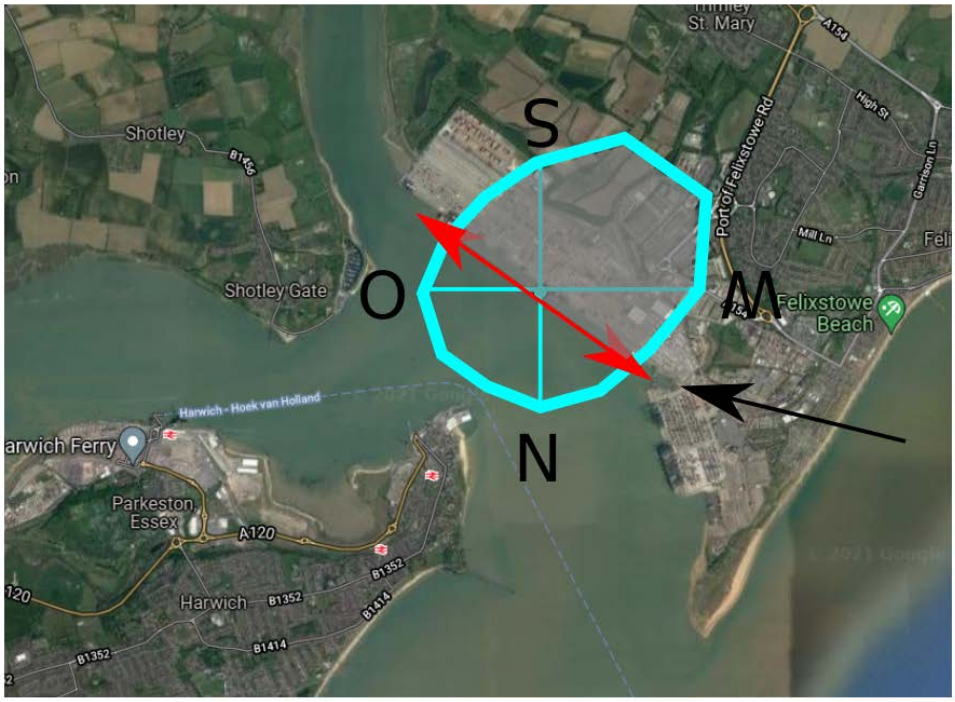
Expectation was to find only BIO Beads. Field survey showed that, indeed, they are found in large numbers but there is an even greater amount of 'normal' nurdles. However there is no petro-chemical industry in Felixstowe and therefore no production of nurdles. There's a lot of harbour activity of course but the main thing is logistics: getting things where they should be.

Because it is assumed that the BIO Beads and the 'normal' nurdles have different sources they are treated independently from each other hereafter.

'Normal' nurdles

To understand the large amount of nurdles (1,000,000?) on the west side of the Felixstowe harbour the schematic wind rose was mirrored (rotation over 180^0) and projected on the quay. Prevailing winds are from the south west. Because the quay is oriented north-west-south-east most of the time the wind will push (floating) plastic against it. This is visualised in the illustration below with the grey (darkened) part in the wind rose situated on the harbour site.
If the wind blows from, roughly, north to east plastic is transported in the direction of Shotley and Harwich. This is the case 20 to 30% of the time. With those wind directions it takes some time for the plastic to 'come loose' because it floats in the lee of the high quay but eventually this will happen, helped by the prop water of arriving and leaving ships.

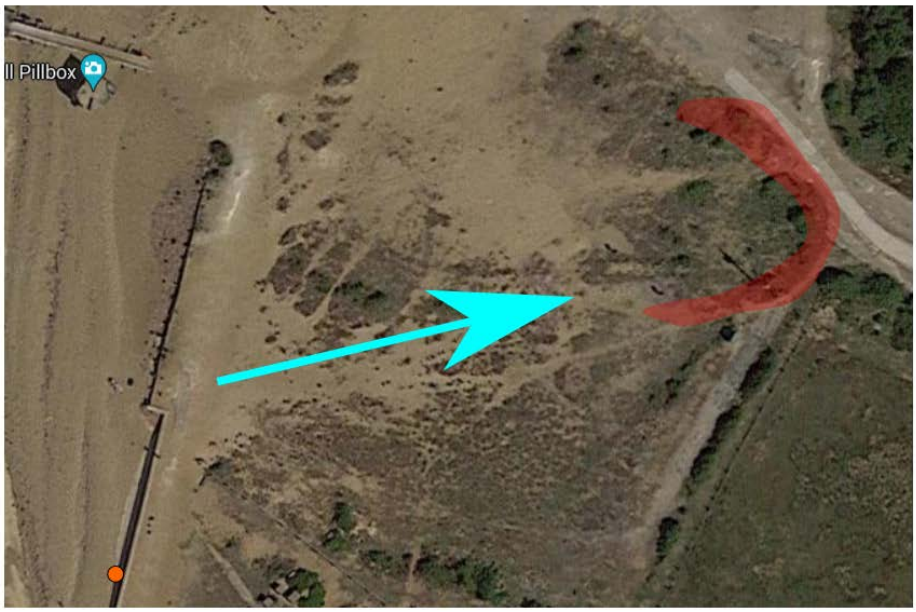
With the prevailing winds (~60% of the time) it is transported inland or direction North Sea (red arrow). Normally the flow velocity at the bank of a river is modest (and will be zero where the water meets the bank) however because the fairway must be kept deep for the ships to dock the velocity along the quay due to tide current is high.



With prevailing winds and falling tide the plastic floats to the east along the quay and will get stuck in the angle indicated by the black arrow. If one should want to catch plastic this is a very good location to do so.
If tide is rising the direction will be more inland. It depends on the force and direction of the wind whether the plastic stays in the east angle. With winds coming from the south it will be transported along the quay to the west until it reaches the end. There it is pushed to the bank and will not be able to float back when tide is falling. If one should want to catch plastic this would also be a good location.
With high water due to north westerly storms the plastic will be pushed further into the angle behind the quay (location 3).

This explains roughly why there is so much plastic and nurdles on the west side of the quay. The source must be in Felixstowe harbour. With the transfer of goods, big bags or other packages are torn as a result of messy work and apparently the spills are not cleaned up well. With heavy downpours the nurdles leave the site trough the sewers. Once in the water distribution is as described above.
Especially with north to north westerly winds (~10-20%) the nurdles will leave the estuary and float to the North Sea. That this process is really happening is shown by the findings on location 1 and 2

In location 2 the numbers found were low. This was not only because there are less to be found (described above) but probably also because the search wasn't conducted thoroughly enough.



The nurdles shown in Annex II were found at the orange dot. With north westerly storms the water will be high here, the waves coming from the inside of the harbour will also be high and top over the defence. This is visible in the picture by the dry gullies oriented west-east (blue arrow). It is assumed that there must be more nurdles in the red area at the highest waterline.

The sea itself can't be the source of all these nurdles. Every now and then a single nurdle might float in accidently but prevailing winds keep them out most of the time. With north westerly storms a lot of water comes in but at the same time the wind will keep the surface water layer out (in which the nurdles float).

Bio Beads

The same applies for the Bio Beads. They might follow the same route as the normal nurdles but this is less likely than the leaking route from the sewage water treatment plant in Ipswich.
These Bio Beads are used as a bio medium for bacteria to grow on and do their purification labour. The volumes traded will therefore be relatively small and arrive with a low frequency. Once the tanks are filled with Bio Beads these will not be replaced often.

The volume found on the beaches in the Netherlands was significant which means that a large quantity must have leaked in a very short time span. Otherwise it wouldn't have washed up on the beach in a continuous ribbon.
Furthermore the assumed leakage coincides with very heavy downpours on this part of England. Therefore the probability that the Bio Beads leaked from Cliff Quay Sewage Treatment Works is high.

If they did, they will have been efficiently transported by the river downstream. Efficiently because wind is less dominant in the upper part of river Orwell with hills and trees and with a river discharge being very high due to heavy rainfall. In the design of the flood barrier a discharge of 100 m^3/s is taken into account (lit 2). Part of the Bio Beads will have washed up on the north bank somewhere between Orwell Bridge and Shotley (location 4). At Shotley, prevailing winds becoming more dominant there, will have pushed part of them to the Felixstowe quay, another part will have floated into the North Sea. Being transported with the wind and the tide they ended up on the beach between Rotterdam and The Hague 12 days later.
The Bio Beads that floated against the quay will have been transported to location 3 (Felixstowe-West) as soon as the conditions were favourable.

Transportation upstream with high water levels after deposits is estimated as being modest because high water occurs with north westerly winds. Although a bigger volume of water is flowing in the direction of Ipswich under these conditions, the wind will hamper the surface layer (in which the plastic floats) in reaching locations upstream.

Conclusions

There are at least one million nurdles on the north bank of river Orwell. At the same time the estuary of Stour and Orwell is considered to have a high nature value: these two don't match.

The probable source for the normal nurdles is Felixstowe harbour.

The probable source for the Bio Beads is the Sewage Water Treatment Plant of Anglian Water in Ipswich.

This information should trigger the Environment Agency because obviously the conditions in the permits granted haven't been met.

The Bio Beads found on several occasions on Dutch beaches originate in all probability from Sewage Water Treatment Plants on the south east coast of England.

It is very strange that engineers design a water purification system that pollutes water. This is an insult to the profession and a denial of the value of nature.

Literature

1. Bio-Bead Pollution on our beaches; Wallerstein, C. ; July 2018.
2. Strategic Flood Risk Assessment, Ipswich Borough Council; AECOM; 2020.

Annex 1, Press Articles

Column @SjaakBral

SJAAK BRAL

Theresiakerk

De Theresiakerk wordt nog niet gesloopt. Dat duurt nog een half jaar. Tenzij de buurt met een goed doortimmerd plan komt - en ik heb een suggestie.

Het gaat niet alleen om nieuwe plannen, het gaat nog meer om de financiering van deze plannen. Daar heb ik ook een oplossing voor. Geld is noodzakelijk, dat weet ook de pleitbezorger van het uitstel, de Haagse Stadspartij. Hun raadslid Peter Bos vindt het uitstel prachtig, maar weet dat zonder investeerders de monumentale kerk uit 1931 ten prooi valt aan degenen die de laatste jaren in onze stad oprukken gelijk wolven op de Veluwe: de projectontwikkelaars. De hele stad is inmiddels een project met een ontwikkelaar.

De haast en de schaalgrootte van dit college van b en w om fors te bouwen is ingegeven door een demografische tsunami die op ons afkomt: jonge mensen en mensen met een kleine beurs. Die kunnen, als wij naar de eeuwige jachtvelden zijn vertrokken, door-stromen naar de huizen waar u en ik nu in zitten. Begrijpelijk.

Maar waarom moet ieder gebouw in deze verdomde stad ineens een woning worden omdat daar geld mee te verdienen valt? Is er nog iemand die opstaat en zegt: de Theresiakerk, daar moeten we wat anders mee doen? Gelukkig wel. Onlangs mocht ik in de Brabantse plaats Bemmel optreden in een theaterkerk. De lokale bevolking heeft met tweehonderd vrijwilligers een indrukwekkende cultuurplek gecreëerd. Natuurlijk wordt er ook verhuurd. Op het podium waar ik 's avonds stond had 's middags een doodskist gestaan. Op zo'n moment is het gewoon weer even een kerk; zowel voor de overledene als voor mij. Waarom niet zo'n majestueus pand als de Theresiakerk bevorderen tot tempel van de hoge en lage kunsten? God weet dat de wijk zoiets hard nodig heeft. Iedereen is welkom als 'ie zijn of haar cultuur wil uitwisselen. In welke vorm dan ook. De naam heb ik ook al: Forum voor Democratie. Maar dan echt. Financiering: stroomt het geld van de verkoop van de aandelen Eneco binnen, pomp straks ook eens een flink deel van die honderden miljoenen in de mensen die hier wonen, en niet alleen in oplaadpalen.

> Theresiakerk bevorderen tot tempel van hoge en lage kunsten

Excuses aan dokter

DEN HAAG In AD Haagsche Courant van 12 maart plaatsten wij een artikel over keizersnedes: 'Moeders trekken aan de bel; psychische nazorg van groot belang'.

Door een misverstand stond daarbij een foto waarop dokter Rossing, destijds arts in opleiding bij Haaglanden MC, herkenbaar in beeld was. Rossing en het ziekenhuis hadden daarvoor geen toestemming gegeven. Bovendien wekt het fotobijschrift de indruk dat deze dokter betrokken was bij de mislukte anesthesie waarover in het artikel wordt geschreven. In werkelijkheid was Rossing aanwezig bij een andere keizersnede die wel succesvol verliep. Bij die operatie werd de betreffende foto genomen.

Wij hebben het ziekenhuis en dokter Rossing onze excuses aangeboden. De online versie van dit verhaal op AD.nl is aangepast.
Hoofdredactie

John

DEN HAAG

Fietser klapt op klep vrachtauto

Een fietser raakte gisteravond zwaargewond doordat hij tegen de opstaande klep van een vrachtwagen aanreed bij de Nunspeetlaan in Den Haag. De vrachtwagen was ter hoogte van de Terletstraat aan het lossen toen de fietser tegen de klep botste. Het slachtoffer is per ambulance naar het ziekenhuis vervoerd. De politie bekijkt hoe dit kon gebeuren.

DEN HAAG

Ilse DeLange komt naar Parkpop

De organisatie van Parkpop heeft de eerste namen bekendgemaakt van optredende artiesten tijdens de gratis festivaldag op zondag. Onder anderen Ilse DeLange, Ronnie Flex en Maan maken hun opwachting op 30 juni. Parkpop duurt drie dagen en begint op vrijdagavond met optredens in de binnenstad. Zaterdag is het betaalde Parkpop Saturday Night.

DEN HAAG

Denk wil vlag in de Statenzaal

De partij Denk wil graag een Nederlandse vlag in de Statenzaal in het provinciehuis van Zuid-Holland. De partij wilde eerder deze week al een voorstel indienen om de vlag direct te plaatsen, maar de meerderheid van de Statenleden vond de eerste beschouwende bijeenkomst in de nieuwe samenstelling niet het juiste moment om erover te stemmen. Denk is een nieuwkomer.

Den Haag

Nieuwe app voor het uitgaansleven

De oude en huidige nachtburgemeesters van Den Haag, René Bom en Sjoerd van Schuylenburch hebben gisteren de uitgaans-app Nocto in gebruik genomen. Die is bedoeld om binnen een straal van tien kilometer foto's en video's met vrienden te delen vanuit favoriete horecagelegenheden.

▲ Bianca Tiegelaar verzamelt op het 's-Gravenzandse strand wat korrels om te laten onderzoeken. FOTO THIERRY SCHUT

Strand ligt vol plastic korrels

Het Westlandse strand tussen Hoek van Holland en Monster lag gisterochtend bezaaid met zwarte plastic korrels en ook langs de Haagse kust werden ze waargenomen. Rijkswaterstaat doet onderzoek naar hoe schadelijk de korrels zijn.

Lisa Vos
Fred Vermeer
's-Gravenzande

De zwarte plastic korrels hebben wel wat weg van de rubberen korrels die op kunstgrasvelden zijn uitgestrooid. Ze zijn afkomstig uit containers, die het vrachtschip MSC Zoe in de nacht van 1 op 2 januari bij de Duitse Waddeneilanden verloor. Het plastic verpakkingsmateriaal spoelde deze week ook in onder meer Zandvoort aan.

Wandelaarster Bianca Tiegelaar trof op het strand bij Vlugtenburg in 's-Gravenzande een kilometerslang spoor aan en schrok zich rot. „De situatie is ronduit zorgwekkend", zegt Tiegelaar vol afschuw. Ze zag duizenden piepkleine plastic korrels liggen in een lang lint. „Het ligt helemaal vol."

Bulldozer

Al zijn de korrels, 'nurdels' genoemd, met het blote oog haast niet zichtbaar, ze zijn een van de grootste bronnen van vervuiling, meent Tiegelaar. „Dit is een milieuramp. Het is afval en zwerft in onze zee." Tiegelaar meldde de korrels direct. Toen zij even later weer ging kijken, waren ze weg. Althans, voor het oog. „Iemand is er met een grote bulldozer overheen gereden. Nu ligt alles onder, in plaats van op het zand." Ze zucht: „Niet een heel slimme actie."

Het opruimen van de kleine korrels is lastig, weet Tiegelaar. „Had maar een voorbeeld genomen aan Schiermonnikoog. Daar wordt een speciale stofzuiger ingezet om de korrels die zijn aangespoeld op te ruimen. Nu de korrels in het zand liggen, weet ik niet of dat nog kan."

Ook strandbezoekster Petra van der Ende was zich rot geschrokken. „Verschrikkelijk. Het eerste dat in mij opkomt: hoeveel beesten hebben dat ingeslikt? Het is om te huilen."

> Dit is een milieuramp. Het is afval en zwerft in onze zee
>
> —Bianca Tiegelaar

De gemeente Westland heeft overleg gevoerd met Rijkswaterstaat en gisterochtend al opruimwerkzaamheden verricht. Rijkswaterstaat heeft ook op het Haagse strand onderzoek gedaan. Bianca Tiegelaar nam van de Westlandse stranden een kilo korrels mee en stuurt die op voor nader onderzoek.

Strand ligt vol plastic korrels = Beach full of plastic granules

▲ Het strand van de Maasvlakte is bezaaid met zwarte plastic korrels. © Bart Koppe

Strand Maasvlakte en Hoek van Holland bezaaid met zwarte plastic korrels

Het strand van de Maasvlakte is bezaaid met zwarte plastic korrels. Strandjutter Bart Koppe trof een kilometerslang spoor aan. Ook andere stranden in Zuid-Holland kleurden zwart door de 'steentjes'.

Nikki Catlender en Yamilla van Dijk 01-04-19, 14:33

Annex II Field visit: deposits

location	1
location	Harwich Fort
date	9-9-2021
number per m^1	1
length of deposit	50
surface total	50

Nurdles Harwich Fort: the black one on the right is a Bio Bead

The nurdles were found in and under the (fresh) seaweed roll

location	2
location	Felixstowe landguard (inside)
date	9-9-2021
number per m^1	5
length of deposit	10
surface total	50

Nurdles landguard: the black ones on the right are Bio Beads


Deposit Landguard: nurdles were found in and under the weed

location	3
location	Felixstowe harbour west
date	9-9-2021
number per m^1	Hundreds/ thousands
length of deposit	200
surface total	100,000 – 1,000,000

If you need reading glasses you won't find them without

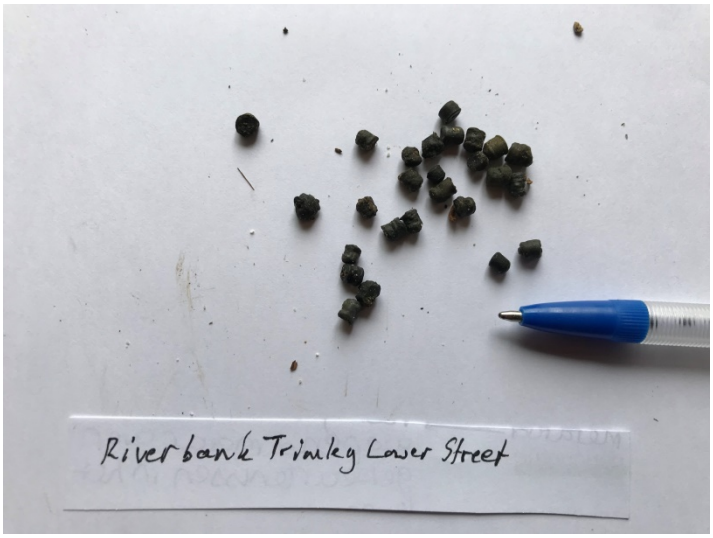
The quantities in the angle (A) of the deposit are the largest. Estimation by surface counting wasn't possible here. There are too much nurdles on a width of several meters. When digging into the organic debris more nurdles are found. There could be up to one million here.

Picture of nurdles on a trunk

In more detail

In more detail

location	4
location	Riverbank Trimley Lower Street
date	9-9-2021
number per m^1	10
length of deposit	10
surface total	100



Only Bio Beads were collected (there were also normal nurdles found)

location	5
location	Ipswich Orwell bridge
date	9-9-2021
number per m^1	10
length of deposit	100
surface total	1000

The wheel shaped plastic item indicated by the pen is also a bio medium which is used in waste water treatment
Assisted Moving Bed (AMB) Bio Media | MBBR Wastewater Filter (dasusa.com)

The nurdles were found where the beach meets the vegetation

3.2.2 Case Hull

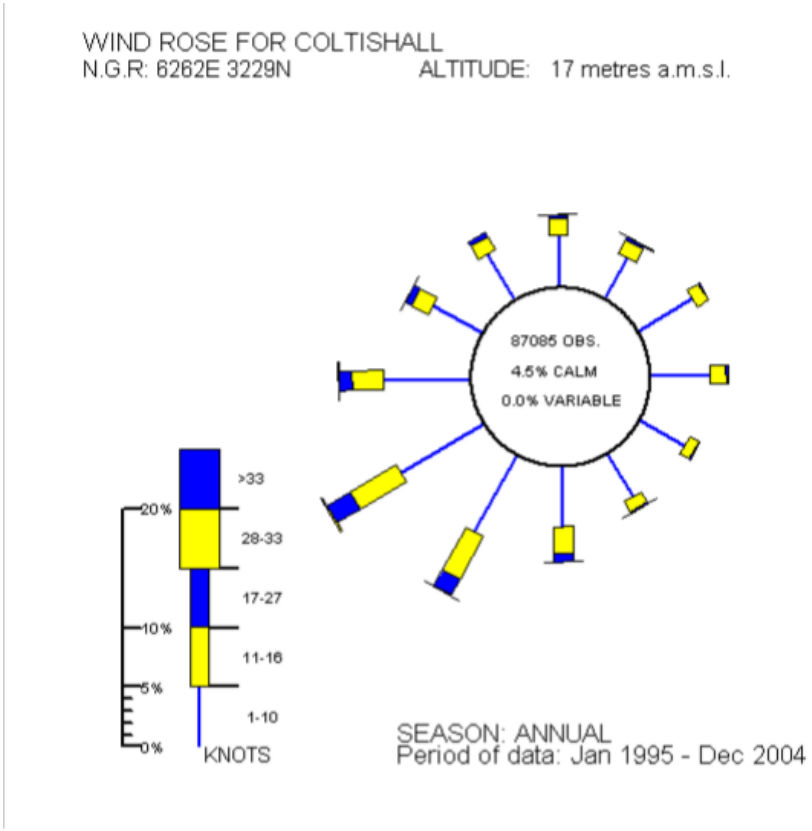
Nurdles Humber
28-9-2021

Contents

Plastic nurdles in the Humber Estuary

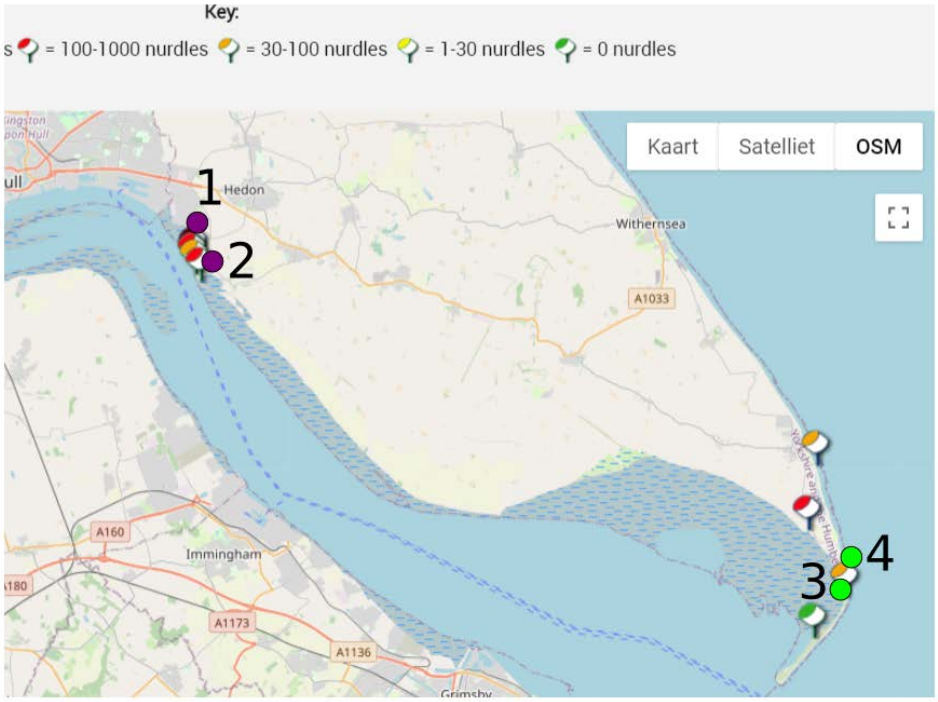
Introduction
Because Hull is situated at an estuary which is oriented northwest-southeast and has a Petro Chemical site (Salt End), a visit was paid to find out whether this might be a nurdle source leaking into the North Sea.

Wind and high water levels
The Humber estuary is tidal dominated (lit. 1) . The highest water levels occur during north westerly storms (lit. 2). This is due to the fact that water whips up in the southern part of the North Sea. Both in the Netherlands (Zeeland) and in the south east of England very high levels occurred during the north west storm of 1953.
These are extremes however because most of the time the wind comes from south westerly directions as shown below in the wind rose, considered to be representative by Met Office, for south east England (Coltisham, Norwich).



Deposits

With the predominant winds in mind, the Petro Chemical site (Salt End) and the information given by the Great Nurdle Map (https://www.nurdlehunt.org.uk/nurdle-finds.html), 4 locations were selected for a field visit.



(More detailed information on the nurdles found in 1 and 2 is given in Annex I).

Sources

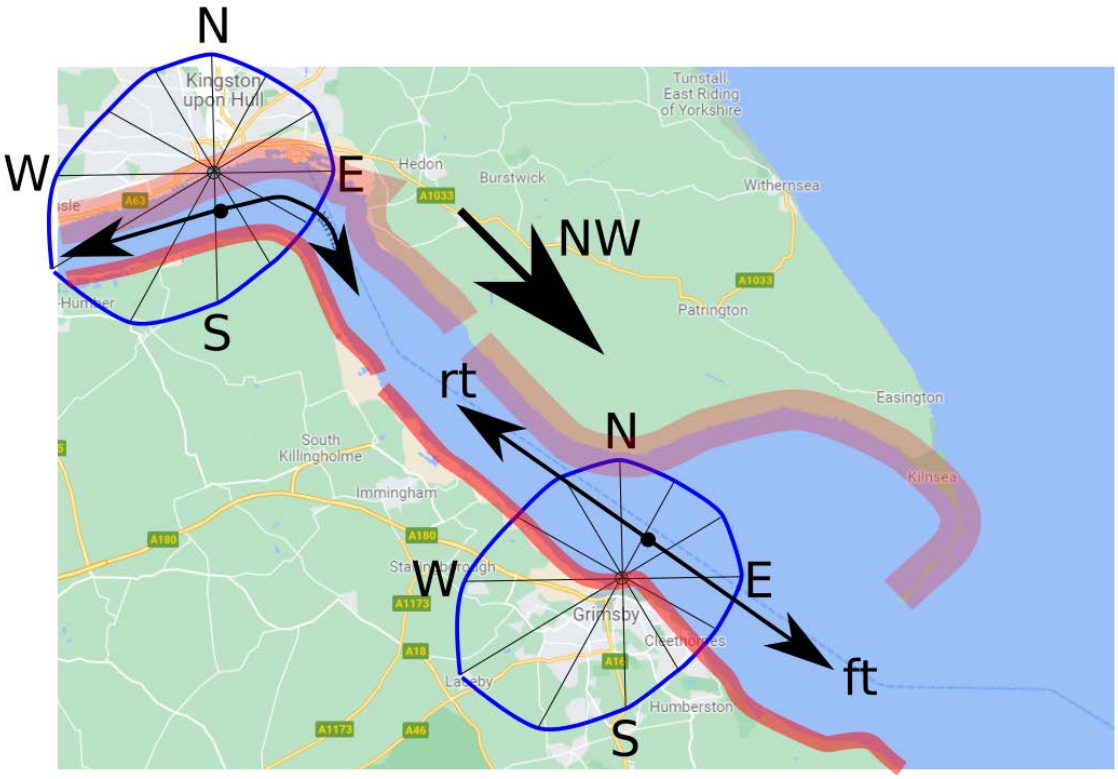
Since 2004 Mitsibushi produces soarnol nurdles at Salt End. According to its website https://mitsubishichemical.co.uk/ these weigh 1,21 g/cm3 which means that if they leak they would sink.

Mitsubishi site at Salt End

There might have leaked nurdles before 2004 but if so, it is estimated that there would be even a lot more nurdles in this cove. It is more likely that the nurdles found here originate from the harbours of Hull and Grimsby (see below).

Current and wind: floating direction

To explain why the nurdles are found in the places that are given in the illustration above (nurdle map with 4 locations), the schematized wind rose and tide current are projected on the harbour mouths of Hull and Grimsby.
During transfer of nurdles every now and then accidents occur. Because of messy handling and cleaning part of the spilled nurdles end up directly in the harbour or indirectly after rain showers through the sewage system.
If this assumption (no check) is right there must be clouds of nurdles floating around in the harbours.



Most of the time winds are from the south west. For Hull this means that the nurdles (and other plastic) floats back (rising tide = rt) and forth (falling tide = ft) with the tide at the quay. Because the tidal range is considerate with 7.2 m (lit. 1) harbours on the Humber make use of sluices to better manage handling of goods. Clouds of nurdles and other plastic will be floating around in these harbours. Most of the time plastic will stay inside but it keeps moving by prop water and, when wind turns to more northerly directions, plastic will be sluiced out to the Humber. When the wind turns to more westerly directions, the nurdles (outside in the Humber) will float to Hedon Haven. They are blown into the cove there and wash up on the bank. With high water due to north west storm they

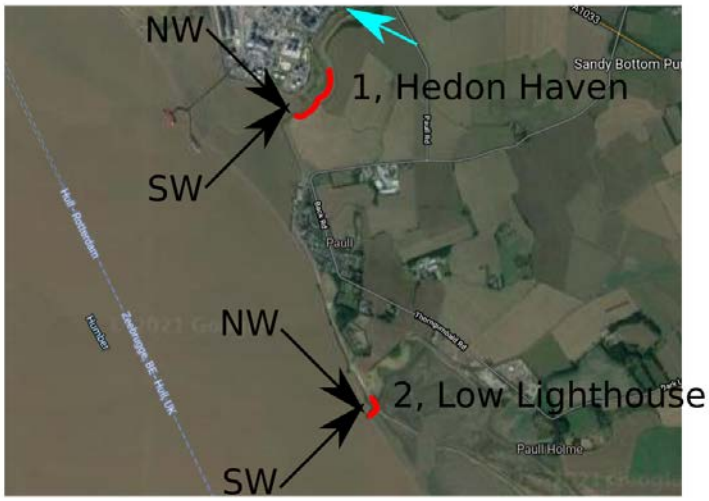
will be pushed high up on the bank. The nurdles will stay there for centuries and will slowly disintegrate.
In Grimsby the same process occurs. Because wind direction is outward most of the time, it is estimated that nurdles and plastic leave this harbour more easily. Once outside a large part will cross the Humber.

To get an idea of floating time and distance, it is assumed that wind force will be transformed into about 5% floating velocity.
(The assumption that the floating speed is about 5% of the wind force, is derived from research on surface transport of oil in which conversion of wind into floating should be from 2.5 to 4 percent. https://www.ncbi.nlm.nih.gov/books/NBK220700/.
Because oil is a coherent liquid with a certain viscosity it is likely that individual plastic nurdles that are also lighter will float somewhat faster = 5 %).

If this assumption is right the cross over at Grimsby (4 km of width) with average south west wind (4 Bft = 6.7 m/s) will take about: 4000/(6.7 x 5%)/3600 = 3.3 hours
Tidal velocity is on average in the order of magnitude of 1m/s (lit. 4). In 3.3 hours a distance will be travelled of 3.3 x 3600 x 1/1000 = 11.8 km inland or seaward.

Wind, handling, sluicing and tidal current are all independent events so plastic will about follow the wind rose and spread over the banks as drawn above. The amount of plastic on the north east bank will be larger (in the illustration this line is therefor of a bigger width) than on the south west bank.

With storms coming from the north west the highest water levels are reached and the washed up plastic will start to float again and will be transported along the banks until it reaches an obstacle. In corners or coves like Hedon Haven and the Low Lighthouse the old nurdles/ plastic will only be put higher on the bank, supplemented by the new ones. So nurdles accumulate in these places.



Accumulation of nurdles.

(The blue arrow points to one of the runoff water outlets of Salt End: it doesn't play an important role for the nurdles found in Hedon Haven)

The nurdles however, on the stretch from the Low Light House to The Old Hall on the north east bank and from East Halton to Donna Nook on the south west bank, are potentially subject to floating out to the North Sea.
In the Spurn Bight (Kilnsea) nurdles will also accumulate. They were found there by the Marine Conservation Society (Nurdle Map).
In this field visit there were no nurdles found. However this is a sandy beach and after washing up, the nurdles will be overblown with sand.

The same applies to the sea side.

A quiet day on the beach: no nurdles were found on the North Sea (beach) side of the Spurn Bight.

Bio Beads

The two most likely candidates for leaking the Bio Beads (see Annex I) are Pyewipe STC in Grimsby and Hull STW. Pyewipe because it is situated on the bank of the Humber. Hull STW because it probably discharges into the Old Fleet (west side of Salt End).

These Bio Beads are used in sewage water treatment works as a bio medium for bacteria to grow on so they can do their purification labour. In a classic purification plant sludge is used for this purpose. By using Bio Beads the business space of a purification plant can be reduced (lit. 5)
With heavy rainfall or with maintenance and accidents, the Bio Beads are leaked into the environment. Because they come in large numbers, all at the same moment in time, they have

caused some consternation on several occasions when they washed up on the beaches of the Netherlands.

Column @SjaakBral

SJAAK BRAL

Theresiakerk

De Theresiakerk wordt nog niet gesloopt. Dat duurt nog een half jaar. Tenzij de buurt met een goed doortimmerd plan komt - en ik heb een suggestie.

Het gaat niet alleen om nieuwe plannen, het gaat nog meer om de financiering van deze plannen. Daar heb ik ook een oplossing voor. Geld is noodzakelijk, dat weet ook de pleitbezorger van het uitstel, de Haagse Stadspartij. Hun raadslid Peter Bos vindt het uitstel prachtig, maar weet dat zonder investeerders de monumentale kerk uit 1931 ten prooi valt aan degenen die de laatste jaren in onze stad oprukken gelijk wolven op de Veluwe: de projectontwikkelaars. De hele stad is inmiddels een project met een ontwikkelaar.

De haast en de schaalgrootte van dit college van b en w om forste bouwen is ingegeven door een demografische tsunami die op ons afkomt: jonge mensen en mensen met een kleine beurs. Die kunnen, als wij naar de eeuwige jachtvelden zijn vertrokken, doorstromen naar de huizen waar u en ik nu in zitten. Begrijpelijk.

Maar waarom moet ieder gebouw in deze verdomde stad ineens een woning worden omdat daar geld mee te verdienen valt? Is er nog iemand die opstaat en zegt: de Theresiakerk, daar moeten we wat anders mee doen? Gelukkig wel. Onlangs mocht ik in de Brabantse plaats Bemmel optreden in een theaterkerk. De lokale bevolking heeft met tweehonderd vrijwilligers een indrukwekkende cultuurplek gecreëerd. Natuurlijk wordt er ook verhuurd. Op het podium waar ik 's avonds stond had 's middags een doodskist gestaan. Op zo'n moment is het gewoon weer even een kerk; zowel voor de overledene als voor mij. Waarom niet zo'n majestueus pand als de Theresiakerk bevorderen tot tempel van de hoge en lage kunsten? God weet dat de wijk zoiets hard nodig heeft. Iedereen is welkom als 'ie zijn of haar cultuur wil uitwisselen. In welke vorm dan ook. De naam heb ik ook al: Forum voor Democratie. Maar dan echt. Financiering: stroomt het geld van de verkoop van de aandelen Eneco binnen, pomp straks ook eens een flink deel van die honderden miljoenen in de mensen die hier wonen, en niet alleen in oplaadpalen.

> Theresiakerk bevorderen tot tempel van hoge en lage kunsten

Excuses aan dokter

DEN HAAG In AD Haagsche Courant van 12 maart plaatsten wij een artikel over keizersnedes: 'Moeders trekken aan de bel; psychische nazorg van groot belang'.

Door een misverstand stond daarbij een foto waarop dokter Rossing, destijds arts in opleiding bij Haaglanden MC, herkenbaar in beeld was. Rossing en het ziekenhuis hadden daarvoor geen toestemming gegeven. Bovendien wekt het fotobijschrift de indruk dat deze dokter betrokken was bij de mislukte anesthesie waarover in het artikel wordt geschreven. In werkelijkheid was Rossing aanwezig bij een andere keizersnede die wel succesvol verliep. Bij die operatie werd de betreffende foto genomen.

Wij hebben het ziekenhuis en dokter Rossing onze excuses aangeboden. De online versie van dit verhaal op AD.nl is aangepast.
Hoofdredactie

John

DEN HAAG

Fietser klapt op klep vrachtauto

Een fietser raakte gisteravond zwaargewond doordat hij tegen de opstaande klep van een vrachtwagen aanreed bij de Nunspeetlaan in Den Haag. De vrachtwagen was ter hoogte van de Terletstraat aan het lossen toen de fietser tegen de klep botste. Het slachtoffer is per ambulance naar het ziekenhuis vervoerd. De politie bekijkt hoe dit kon gebeuren.

DEN HAAG

Ilse DeLange komt naar Parkpop

De organisatie van Parkpop heeft de eerste namen bekendgemaakt van optredende artiesten tijdens de gratis festivaldag op zondag. Onder anderen Ilse DeLange, Ronnie Flex en Maan maken hun opwachting op 30 juni. Parkpop duurt drie dagen en begint op vrijdagavond met optredens in de binnenstad. Zaterdag is het betaalde Parkpop Saturday Night.

DEN HAAG

Denk wil vlag in de Statenzaal

De partij Denk wil graag een Nederlandse vlag in de Statenzaal in het provinciehuis van Zuid-Holland. De partij wilde eerder deze week al een voorstel indienen om de vlag direct te plaatsen, maar de meerderheid van de Statenleden vond de eerste beschouwende bijeenkomst in de nieuwe samenstelling niet het juiste moment om erover te stemmen. Denk is een nieuwkomer.

Den Haag

Nieuwe app voor het uitgaansleven

De oude en huidige nachtburgemeesters van Den Haag, René Bom en Sjoerd van Schuylenburch hebben gisteren de uitgaans-app Nocto in gebruik genomen. Die is bedoeld om binnen een straal van tien kilometer foto's en video's met vrienden te delen vanuit favoriete horecagelegenheden.

▲ Bianca Tiegelaar verzamelt op het 's-Gravenzandse strand wat korrels om te laten onderzoeken. FOTO THIERRY SCHUT

Strand ligt vol plastic korrels

Het Westlandse strand tussen Hoek van Holland en Monster lag gisterochtend bezaaid met zwarte plastic korrels en ook langs de Haagse kust werden ze waargenomen. Rijkswaterstaat doet onderzoek naar hoe schadelijk de korrels zijn.

Lisa Vos
Fred Vermeer
's-Gravenzande

De zwarte plastic korrels hebben wel wat weg van de rubberen korrels die op kunstgrasvelden zijn uitgestrooid. Ze zijn afkomstig uit containers, die het vrachtschip MSC Zoe in de nacht van 1 op 2 januari bij de Duitse Waddeneilanden verloor. Het plastic verpakkingsmateriaal spoelde deze week ook in onder meer Zandvoort aan.

Wandelaarster Bianca Tiegelaar trof op het strand bij Vlugtenburg in 's-Gravenzande een kilometerslang spoor aan en schrok zich rot. „De situatie is ronduit zorgwekkend", zegt Tiegelaar vol afschuw. Ze zag duizenden piepkleine plastic korrels liggen in een lang lint. „Het ligt helemaal vol."

Bulldozer

Al zijn de korrels, 'nurdels' genoemd, met het blote oog haast niet zichtbaar, ze zijn een van de grootste bronnen van vervuiling, meent Tiegelaar. „Dit is een milieuramp. Het is afval en zwerft in onze zee." Tiegelaar meldde de korrels direct. Toen zij even later weer ging kijken, waren ze weg. Althans, voor het oog. „Iemand is er met een grote bulldozer overheen gereden. Nu ligt alles onder, in plaats van op het zand." Ze zucht: „Niet een heel slimme actie."

Het opruimen van de kleine korrels is lastig, weet Tiegelaar. „Had maar een voorbeeld genomen aan Schiermonnikoog. Daar wordt een speciale stofzuiger ingezet om de korrels die zijn aangespoeld op te ruimen. Nu de korrels in het zand liggen, weet ik niet of dat nog kan."

Ook strandbezoekster Petra van der Ende was zich rot geschrokken. „Verschrikkelijk. Het eerste dat in mij opkomt: hoeveel beesten heb-

> Dit is een milieuramp. Het is afval en zwerft in onze zee
>
> —Bianca Tiegelaar

ben dat ingeslikt? Het is om te huilen."

De gemeente Westland heeft overleg gevoerd met Rijkswaterstaat en gisterochtend al opruimwerkzaamheden verricht. Rijkswaterstaat heeft ook op het Haagse strand onderzoek gedaan. Bianca Tiegelaar nam van de Westlandse stranden een kilo korrels mee en stuurt die op voor nader onderzoek.

Example of a wash up of Bio Beads on the beach in the Netherlands

Conclusions

The nurdles in the Humber estuary probably originate from the harbours in Hull and Grimsby. At the same time the Estuary of the Humber is considered to have a high nature value: these two don't match.

The probable source for the Bio Beads is Pyewipe STC in Grimsby or Hull STW.

This information should trigger the Environment Agency because obviously the conditions in the permits granted haven't been met.

The Bio Beads found on several occasions on Dutch beaches originate in all probability from Sewage Water Treatment Plants on the south east coast of England.

It is very strange that engineers design a water purification system that pollutes water. This is an insult to the profession. Somebody confuses the means with the end here.

The nurdles that wash up on the stretch from the Low Light House to The Old Hall on the north east bank and from East Halton to Donna Nook on the south west bank, are potentially subject to floating out to the North Sea.

Literature

1. Humber Estuary, Eurosion Case Study, Environment Agency United Kingdom
2. Humber River Basin District, Flood Risk Management Plan 2015-2021, Part A, 2016
3. Hull City Council Strategic Flood Risk Assessment SFRA REP/232639/001 Final | 14 December 201614 December 2016
4. Mathematical Modelling of Tidal Currents in the Humber Estuary, Falconer R.A. et al, 1984
5. Bio-Bead Pollution on our beaches; Wallerstein, C. ; July 2018.

Annex I Field visit: deposits

location	1
location	Hedon Haven
date	28-9-2021
GPS (Google maps)	X=53.72837 Y=-0.23265
number per m^1	100
length of deposit	500
surface total	50,000

Nurdles Hedon Haven: the black, deteriorated, ones upper right (near thumbtack) are Bio Beads, the 3 balls down right are BB-Gun pellets (children's toy)

Hedon Haven

Hedon Haven: most nurdles (and plastic) disappear between the armour rock

Hedon Haven detail

location	2
Location	Low Lighthouse
Date	28-9-2021
GPS (Google maps)	X=53.70895 Y=-0.22708
number per m^1	200
length of deposit	50
surface total	10,000

Nurdles Lighthouse: the black ones upper right are Bio Beads. The pencil points at cut of pieces of electrical wire

Same situation: most nurdles disappear in the armour rock bank. In the background Hull

Lighthouse: detail

location	3, 4
location	Spurn Bight/ Beach North Sea
date	28-9-2021
GPS (Google maps)	X=53.60107 Y=0.14581 X=53.60453 Y=0.14676
number per m^1	0
length of deposit	-
surface total	0

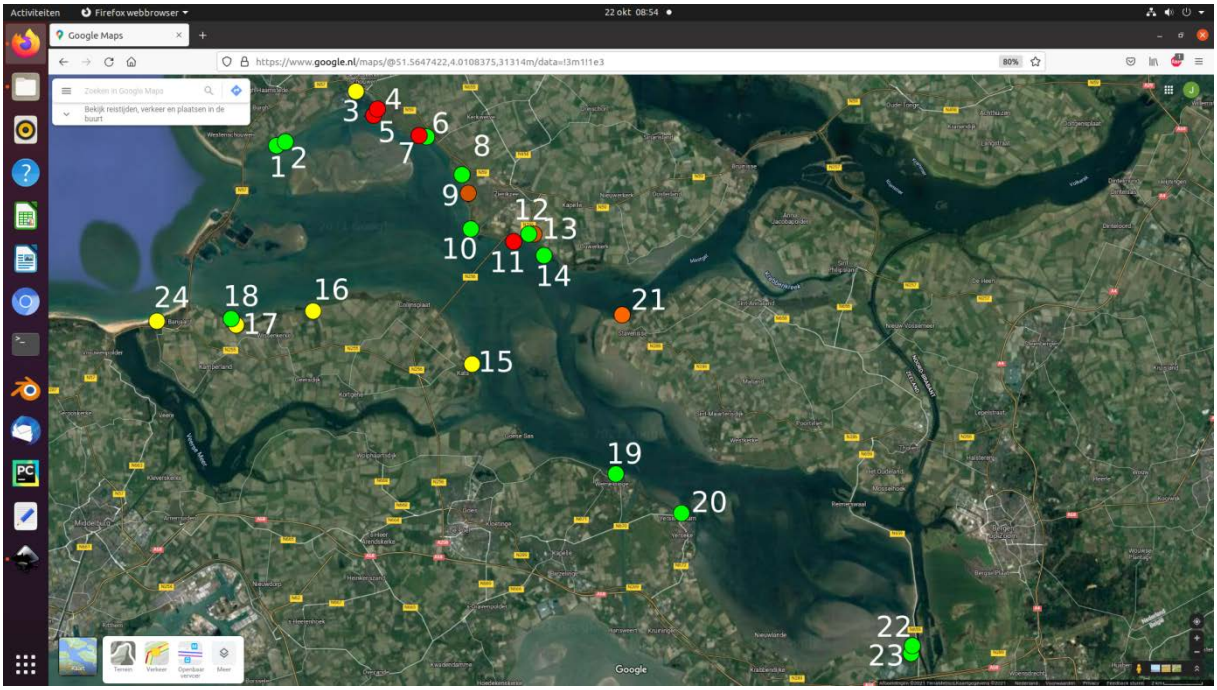
Spurn Bight: nurdles disappear under the sand. In the background Spurn Point.

3.2.3 Case Oosterschelde

Introduction

Contrary to the Westerschelde there are no sources for nurdles from producers or from transfer inside the estuary. The only source here is the North Sea. The image of the nurdle division can therefore be used as a comparison to the situation in the North Sea part of the Westerschelde.

Deposits



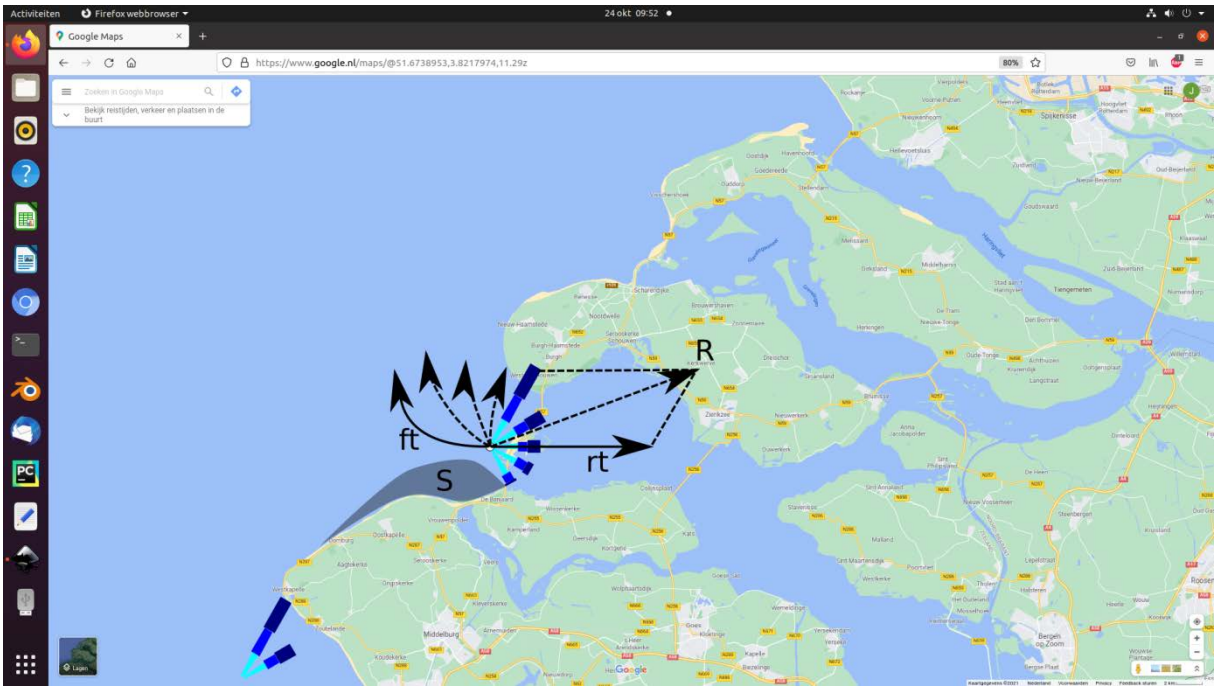
24 locations were visited. The results are in the Annex. Apart from the nurdles (and Bio Beads) some attention was given to plastics spilled by the fisheries and a water purification plant because they can give more information on the distribution pattern of the nurdles.

Source North Sea

It is assumed that the flow of nurdles is diffuse and originates from the east coast of the UK. With the prevailing winds from the south west part of the surge barrier is lying in a ‘nurdle shade’ (S). This is indicated in the illustration hereafter.

Wind and water system

In the illustration the wind and water system is schematized. When the tide rises (rt) nurdles are transported to the north bank (R). The sandbank (Roggenplaat) visible in the deposits illustration above will facilitate this process.



For the wind rose the average 1991-2020 October month was used, KNMI

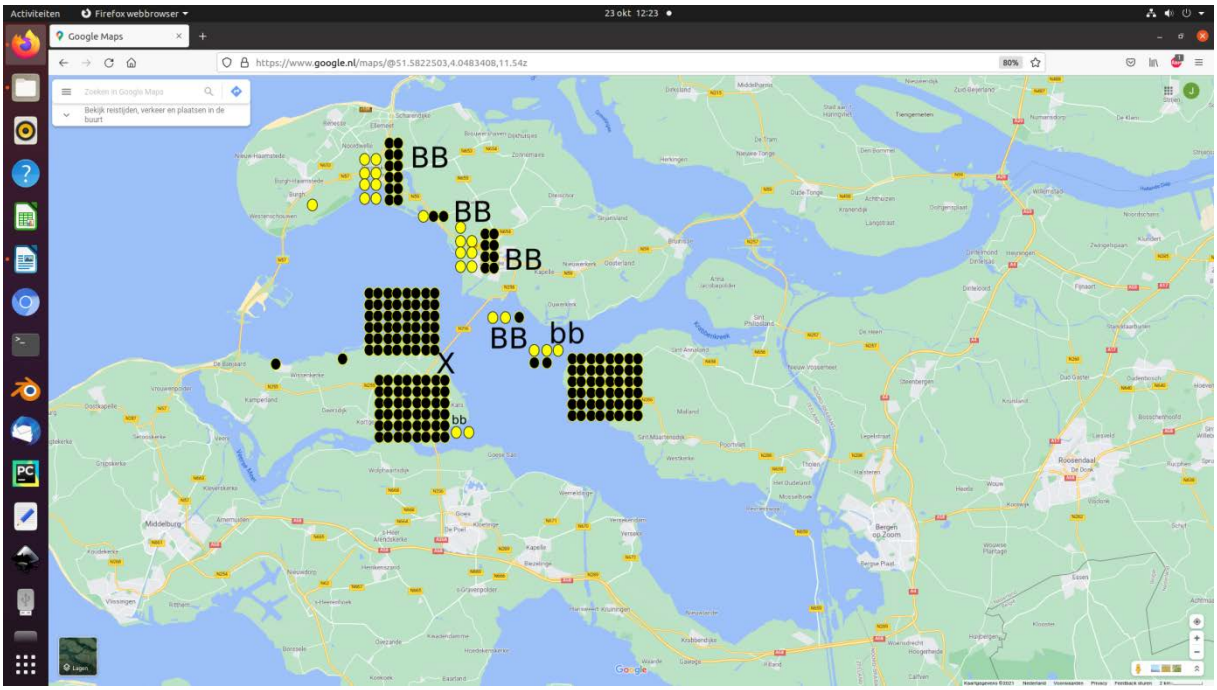
With falling tide (ft) part of the nurdles will keep flowing along the coast and part of them will wash up on the beach north of the barrier. With a storm from the north west they are picked up again and will end up somewhere in the Oosterschelde.

Flow velocity is up to 2m/s in the barrier. On average about 1 m/s because of the tide. Bft 5 is on average 9.3 m/s. If 5% of the wind is converted into floating speed this is about 0.5 m/s. Flow velocity on the bank is 0 m/s. Roughly these variables are therefore in the same order of magnitude and can be combined in further modelling if wished.

There is a nurdle flow to the south bank also (not illustrated with arrows) but this will be smaller because wind from the north/north-west is less common.

Because a lot of Bio Beads are found, the assumption arose that there might be a source in the Oosterschelde itself. However if the patterns of bio media are illustrated on the map and combined with the map of deposits of the normal nurdles (above) they don‘t fit.

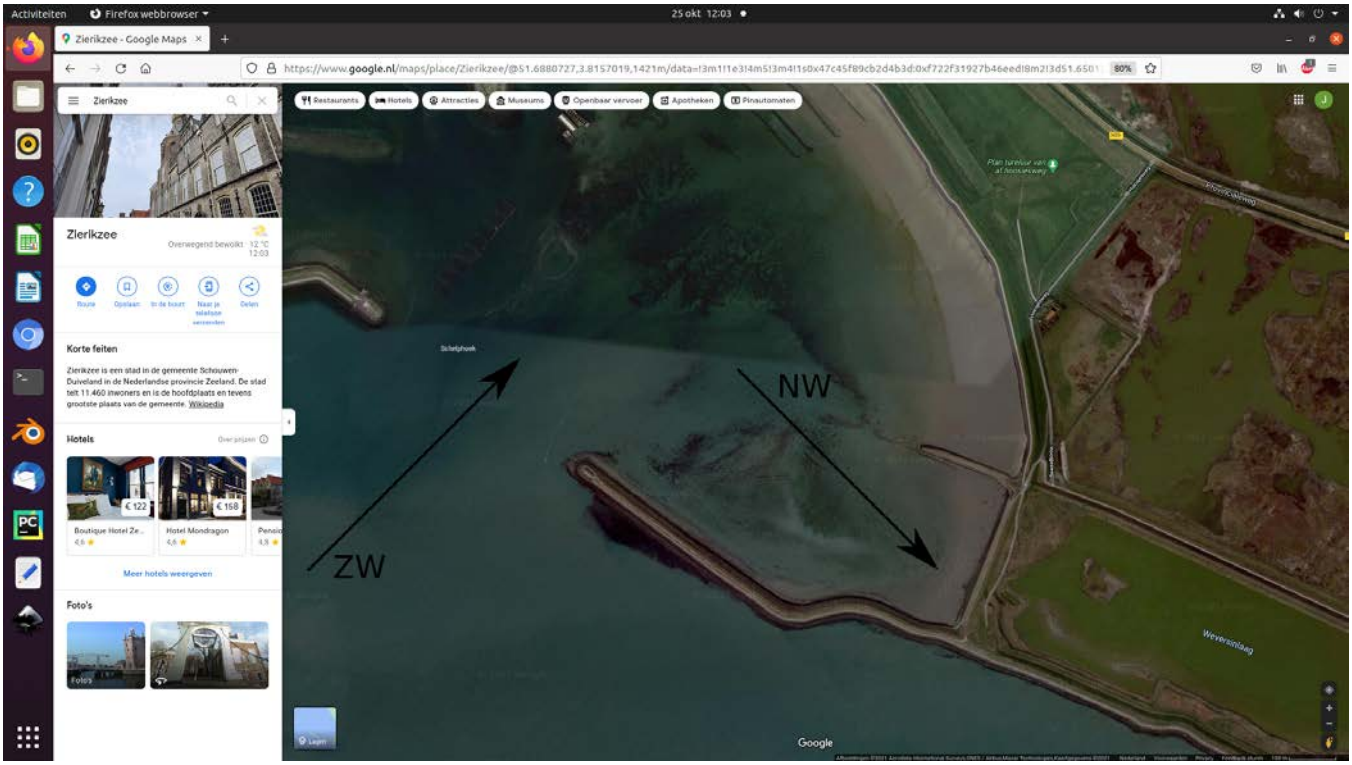
The number of nurdles, Bio Beads and wheel shaped bio media dilute on the way to the end of the estuary. The Kingfish (emission point =X) bio media follow another pattern (see Annex O4/5 for the link). The large numbers found near Colijnsplaat and on Tholen are not part of the data. They were derived from articles in the press.



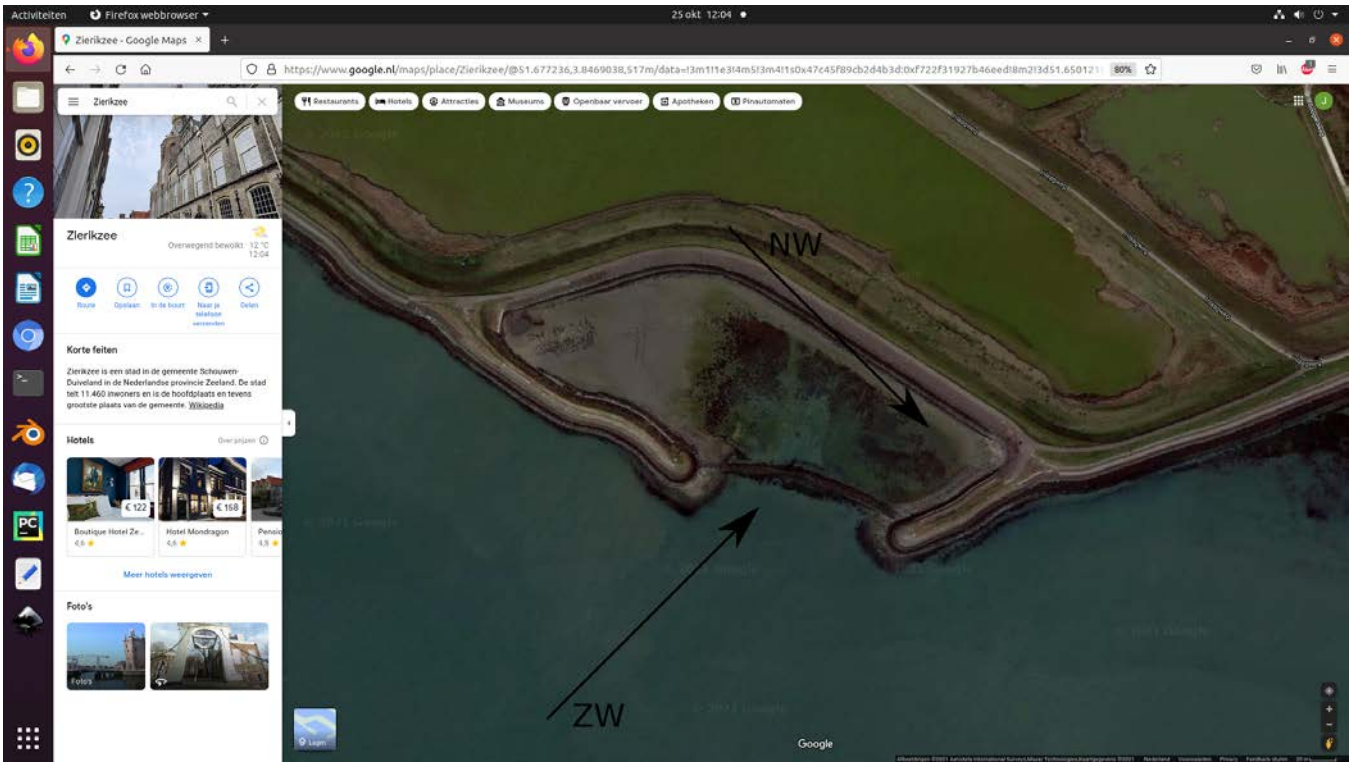
BB = Bio Beads > 1000, bb>100, bb>10; yellow = wheel shaped bio media, black = Kingfish bio media

Catching?

The situation on the hotspots Schelphoek, Kerkerwe and de Val is similar.



Schelphoek



Kerkerwe

De Val

Plastic enters easily with prevailing winds, leaving with north west storms is not possible. It is not very difficult to catch plastic along the banks this way. It is smarter to prevent it from reaching the water.

Conclusions

Concentration of nurdles and Bio Beads diminues towards the end of the estuary.

Because of prevailing winds, the sand bank (Roggenplaat) and the nurdle shade, the number of nurdles on the north bank is higher than on the south bank.

Nurdles are found on the same locations as where part of the bins are situated (‘Doe mee, Verlos de Zee’). These are meant to collect plastic which is gathered by volunteers. Nurdles always come together with other plastic and accumulate on the same locations.

The Oosterschelde is a National Park. A large part of the plastic that is found in the Oosterschelde is caused by ‘the fisheries’: these two don’t match.

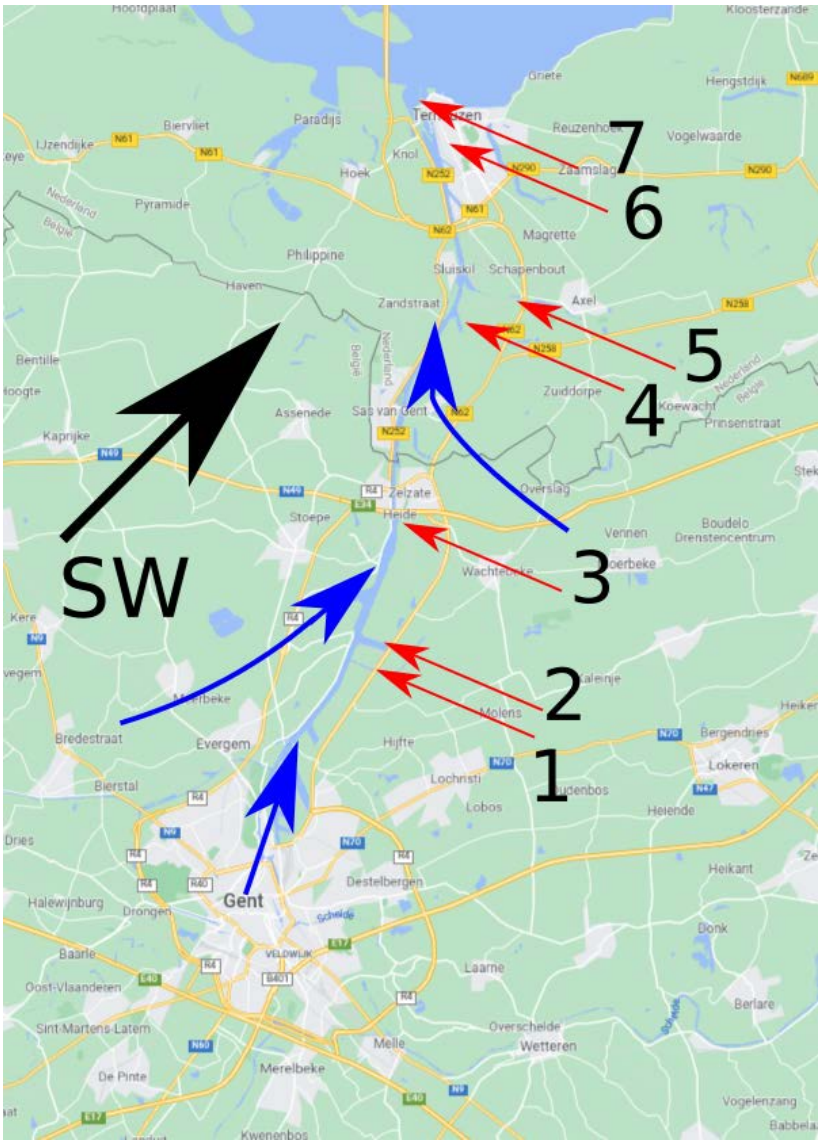
4. Kanaal Gent-Terneuzen

Introduction

A lot of nurdles were found outside the sluice of Terneuzen (deposit 7). This (too) large number did not fit into the pattern of nurdles that was mapped on the south bank of the Westerschelde. Therefor it was assumed that these nurdles originate from the canal itself.

4.1 Water system

This canal was constructed to have a shipping connection from Gent to the North Sea. It also serves as a drain for the discharge of water from the paved area of Gent and the agricultural area on both sides of the canal (blue arrows).



To prevent the canal from salinization from Terneuzen it is fed with water from the Gent region and held at a constant level. This means that the mostly weak current is aimed towards Terneuzen. With the prevailing winds (black arrow) transport of plastic will occur mainly along the east bank.

Because yearly 10,000 sea vessels and 50,000 inland vessels use the canal the water (with floating nurdles) is moving around constantly. (https://www.vnsc.eu/themas/scheepvaart-economie/scheepvaart/).

4.2 Sources

It was decided not to check for sources in the city of Gent itself. There could be several but they are not easy accessible. Furthermore the spilled nurdles will keep floating around in this area because of steep quays of sheet pile.

Nurdles are not only spilled when produced but also during transfer. Companies that handle grain bulk goods like fertilizer, sand, gravel also transfer nurdles (and bio media). An example is 'Vlaeynatie' that has a site in the 'Autrichehaven' (deposit 4).

Whether they comply with the rules is checked occasionally by the authorities. The last time Vlaeynatie was controlled by DCMR was on the 29th of June 2021. It resulted in a report of which the summary can be consulted https://www.dcmr.nl/. There were no violations detected but one of the points for improvement was 'to clean up spillings on the quay in time to prevent them from polluting the water'. Deposit 4 (10,000 nurdles) shows the reason for this point of improvement.

Another example of the fact that theory and practice do not match is 'UNILIN' at the Moervaartkaai (deposit 1).

The UNILIN-crane loads a white grain material onto a conveyor belt

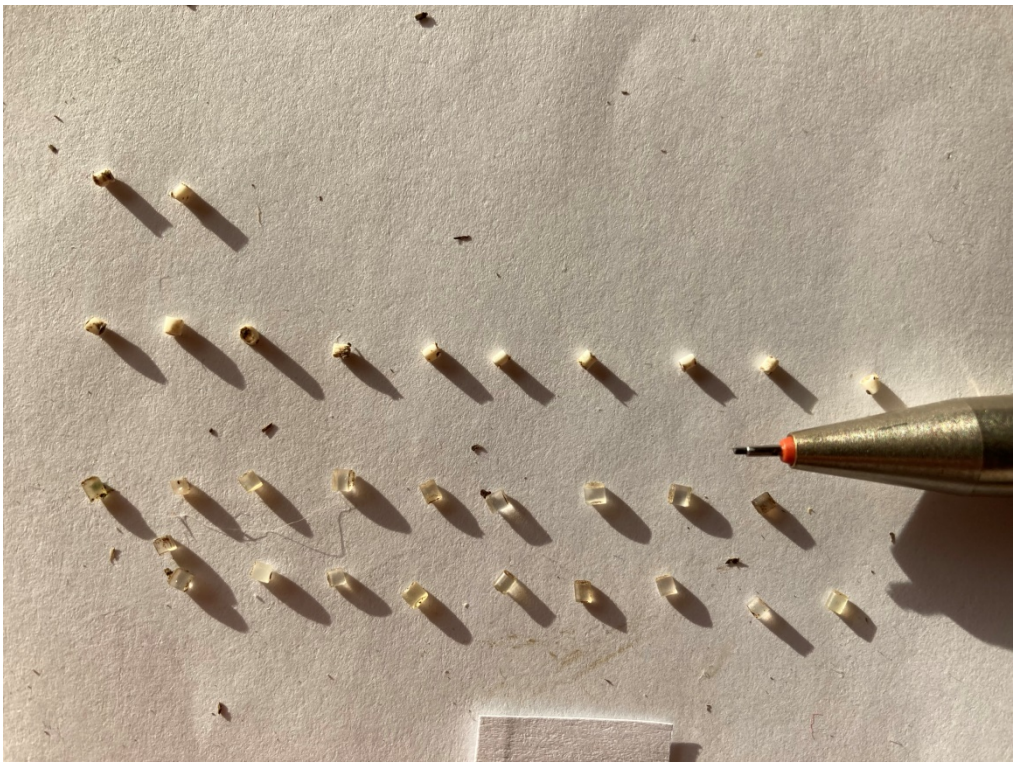
Picture taken from the other side. The white track beneath the conveyor belt and on the quay are spilled grains.

More closely: the white cloud in front of the passing car and on the quay is spilled material

4.3 Deposits

Because transport will be mainly along the east bank of the canal, most nurdles can be found in the coves and harbours on this side (Annex VII).

A new sort of nurdle was found during the field visits in colours transparent, white and black.



Deposit 1: Mini-nurdles? Transparent and white (pencil = 0.5 mm)

Deposit 4: transparent and black

4.4 Conclusions

The canal Gent-Terneuzen is the source for the nurdles found outside the sluice at Terneuzen (deposit 7).
The spilling of nurdles is common practice here as well at the production sites as during transfer from water (ship) to land (truck).
Because plastic transport is mainly along the east bank this is a good location for catching nurdles (and plastic). It is smarter to close the plastic leaks.

5 Clean Sweep?

In its public relations folder the Dutch department of the sector clarifies that they work on a programme that exists already for more than 25 years.

NRK
RUBBER & KUNSTSTOF
We kunnen niet zonder!

Operation Clean Sweep®

Meer informatie

Operation Clean Sweep is een wereldwijd programma. Het bestaat al meer dan 25 jaar. In Nederland wordt het uitgevoerd door de NRK. PlasticsEurope is verantwoordelijk voor Europese bedrijven en publiceert jaarlijks een rapport.

NRK: www.nrk.nl/onderwerpen/zwerfafval

PlasticsEurope: www.opcleansweep.eu

Wereldwijd: www.opcleansweep.org

https://assets.nrk.nl/p/196608/none/Documenten%20downloads%202020/brochure%20nrk%20operation%20clean%20sweep%202020.pdf

If you want to tackle a problem and you still have not succeeded after 25 years then why bother any longer?

It shows that this sector is not able to produce and transport nurdles without spilling. The technology was designed in an era that environment was a factor of minor importance. It obviously does not meet the requirements of today. Leaking is still considered as a calculated economic loss.

In the information there is no reference to the nurdles that leaked into the environment and washed up on beaches, riverbanks and estuaries. These should also be swept clean by the responsible companies.

If this problem is not dealt with more radically by re-engineering and chain responsibility, we will all be invited at the 50-year jubilee.

6. Conclusions

The surface total of nurdles in the Westerschelde and Oosterschelde is estimated 1.9 million. Because not all potential deposits were visited and part of the nurdles are under de debris this number can be multiplied a few times.

Sources are in Terneuzen, the port of Antwerpen (sluices Zandvliet, Berendrecht), port of Vlissingen, ports in south east England (Hull, Felixstowe) and the canal Gent-Terneuzen. Nurdles are spilled both with production and transfer.

The most important mechanisms in the spreading of nurdles are prevailing winds from the south west and storms from the north west.

To further maximize the quality of this method the calculations should be made with state of the art models and 10 minute wind data from the nearest meteorological stations. Furthermore the assumption of 5% conversion wind-floatingspeed should be better defined.
With historical data it might be possible to link part of the nurdles to the responsible producers and transfer companies.

The sector does not do its best to prevent spilling: every day plastic nurdles are added to the huge number that was leaked already.

7 Literature

1. 2021-02; Decarbonisation options for the Dutch polyolefins industry; TNO: A. Negri, T. Ligthart.
2. 2002-09-11; Verbeteren Scalwest model en Bouw Scalwest2000 model, Eindrapport deel II; Royal Haskoning: M.Jansen.
3. 2002-10; Waterbeweging in de Westerschelde, een literatuurstudie, UU: Kramer de, J.
4. 2018-07; Bio-Bead pollution on our beaches, Wallerstein, C
5. 2008-11; MEP/GEP Havendokken Antwerpen, Haskoning-Be, Pals, A; Vercoutere, B.

Annex I methods and assumptions data

Data on precipitation in Terneuzen is only publicly accessible in daily data. The choice to take the days with > 30 mm of rain implies that very heavy short rainshowers that can also lead to an overflow of the drainagesystem, but have a lower total than 30 mm, will be missed.
This can be addressed by using the 10-min data (not publicly available). However these short rainshowers occur with a similar weather type and it is estimated that nurdles that overflowed as a consequence will follow a comparable flow pattern.

The differences in force between the wind in Vlissingen and in Terneuzen will not be large. Even though the wind in Vlissingen will be slightly stronger in force coming directly from the North Sea, the direction will be the same.

Wind ghusts are not taken into account. A bigger wind force from the south west leads to a slight shift to the right of the stretch AB.

The Scalwest2000 model version 2009 was used. In the meantime there have been some changes in the bathymetry by dredging. Because average tide volume and wind direction do not change this will have a negligible influence on plastic transport.

In the explanation that comes with the Scalwest2000-model it is noted that the surface flow should be increased by 15 % (lit 2).

The model Scalwest itself can be used in combination with wind data and historical tide observations to make the calculations more exact.

Furthermore the changes in flow velocity over the width of de Westerschelde are not taken into account (figure 3). In the middle of the gully the velocity is the highest and close to the banks and around the sandbanks it is low (see illustration I-1).

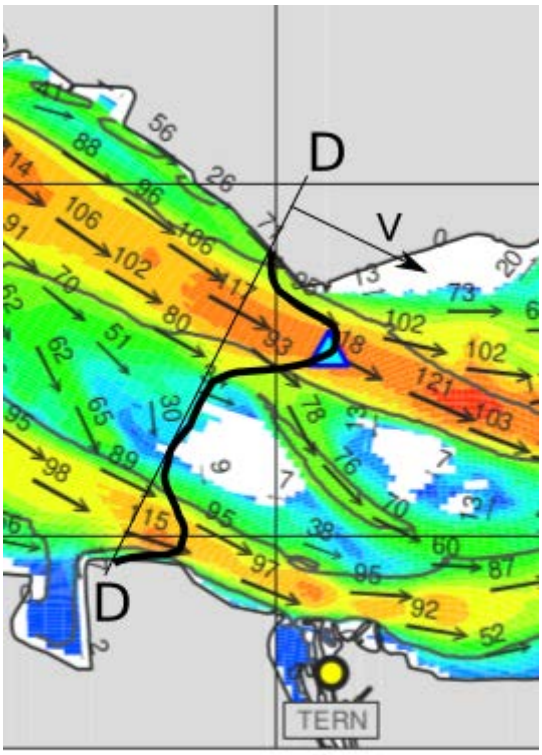


Illustration I-1: flow velocity varies strongly over the width of the Westerschelde

If taken into account the stretch AB will get smaller/ shrink from both sides to its center.
In the figure below the flow paths were calculated for half the velocity.

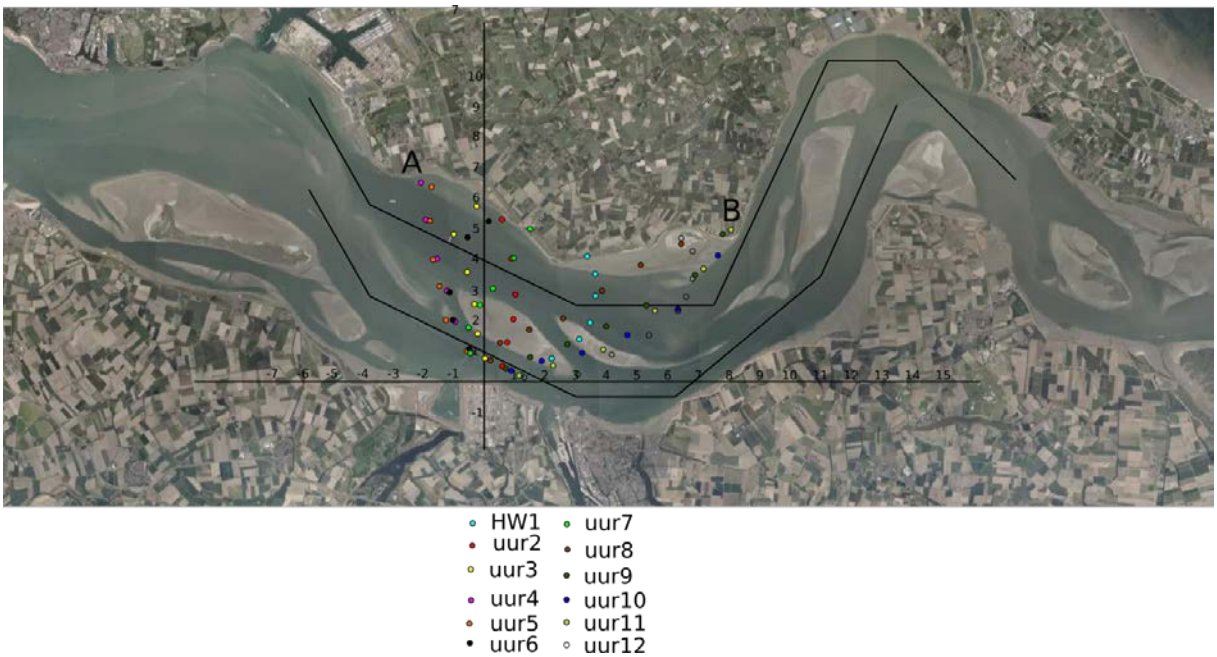


Illustration I-2: Calculated flow paths of nurdles after a rain shower on 28-7-2013 for an average tide cycle: 0.5 v.

In the calculations of the flow paths (fig I-3) use was made of the velocity in the middle of the channel/gully at the height of Terneuzen. This means that differences with the other gullies are not taken into account.

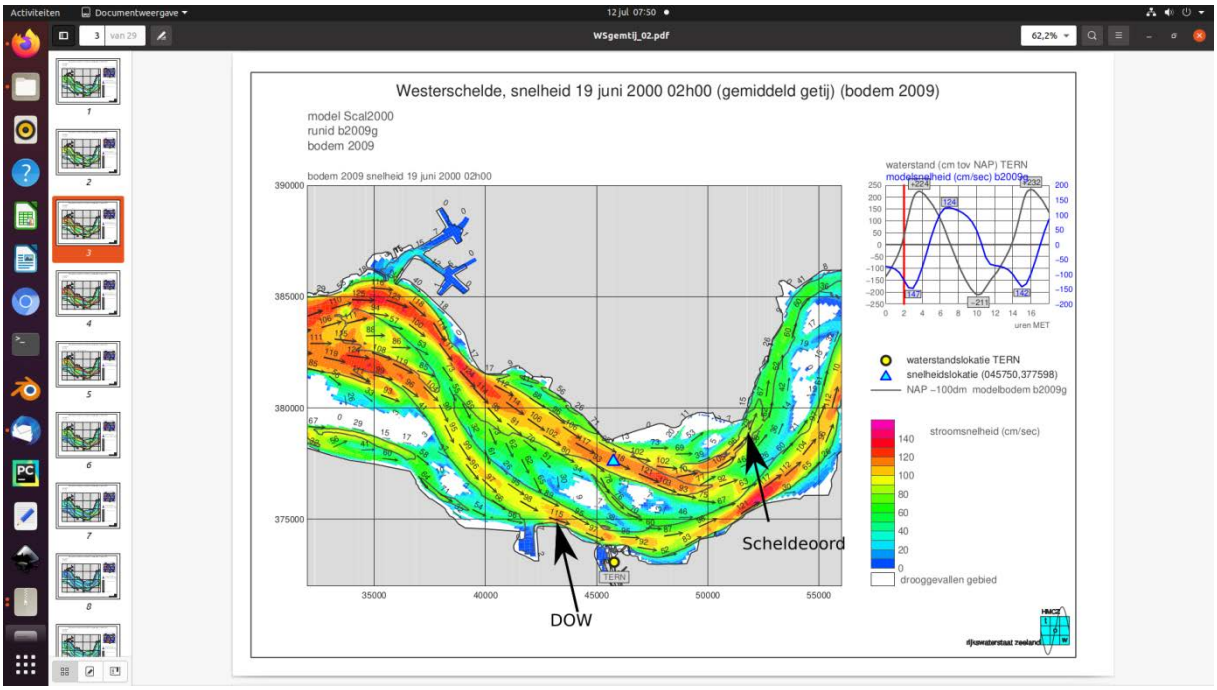
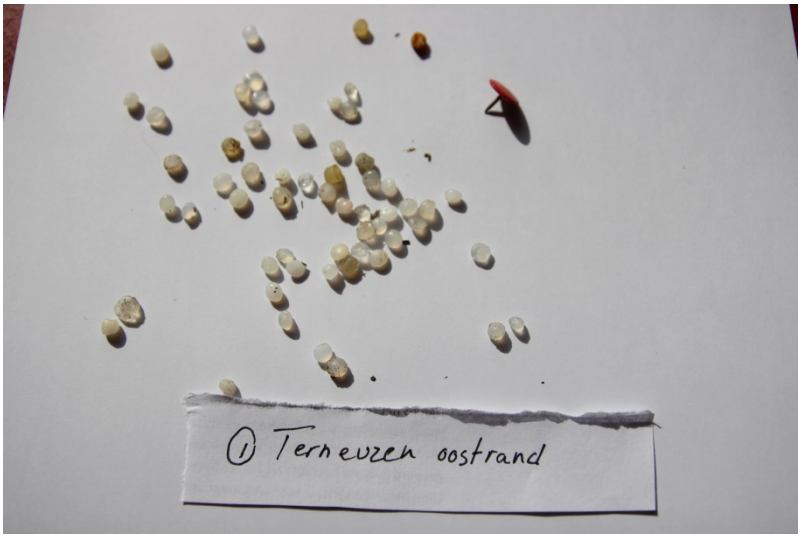


Figure I-3: flow velocity varies in time and on location

The discharge of the river Schelde (per tidal cycle 5 million m^3) is of negligible influence on the tidal current in the Westerschelde (2.2 billion m^3). The influence of the river on the vertical and horizontal water movement becomes noticeable above Antwerpen (lit 3).

Annex II A Deposits Terneuzen south bank Westerschelde

Location	1
Location	Terneuzen oostrand
Date	9-8-2021
coordinates	X=49080; Y=373014
number per m^1	10-100
length of deposit	100 m
surface total	5,000



location	2
location	Kampersedijk
date	9-8-2021
coordinates	X= ; Y=
number per m^1	10-100
length of deposit	100 m
surface total	5,000

location	3
location	Gemaal Campen
date	9-8-2021
coordinates	X= 55482 ; Y=376091
number per m^1	100-500
length of deposit	500 m
surface total	150,000

location	4
location	Werkhaven Walsoorden
date	9-8-2021
coordinates	X=60892 ; Y=377760
number per m^1	100-500
length of deposit	100 m
surface total	30,000

location	5
location	Terneuzen sluis
date	10-8-2021
coordinates	X=45947 ; Y=373512
number per m^1	10-100
length of deposit	250 m
surface total	12,500

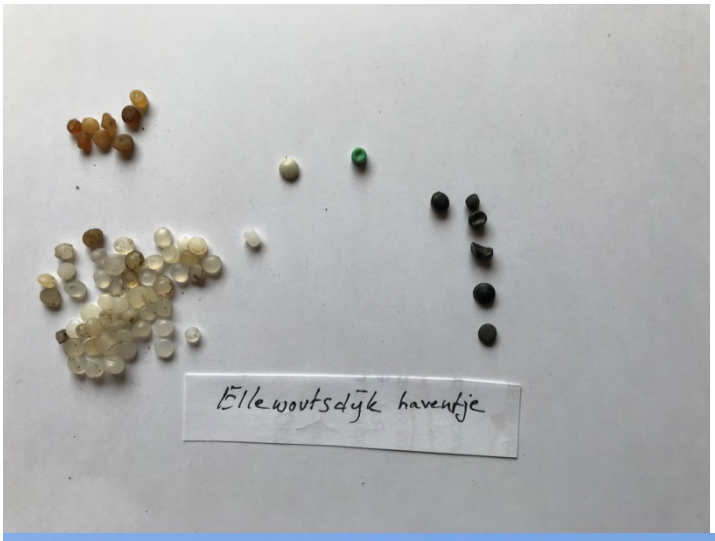
Annex IIB, Deposits Terneuzen north bank Westerschelde

location	
location	Camping Krukel
date	3-9-2021
coordinates	X=41522 ; Y=381873
number per m^1	20
length of deposit	50
surface total	1,000

location	
location	Coudorpe
date	3-9-2021
coordinates	X=43013 ; Y=381315
number per m^1	30
length of deposit	150
surface total	4,500

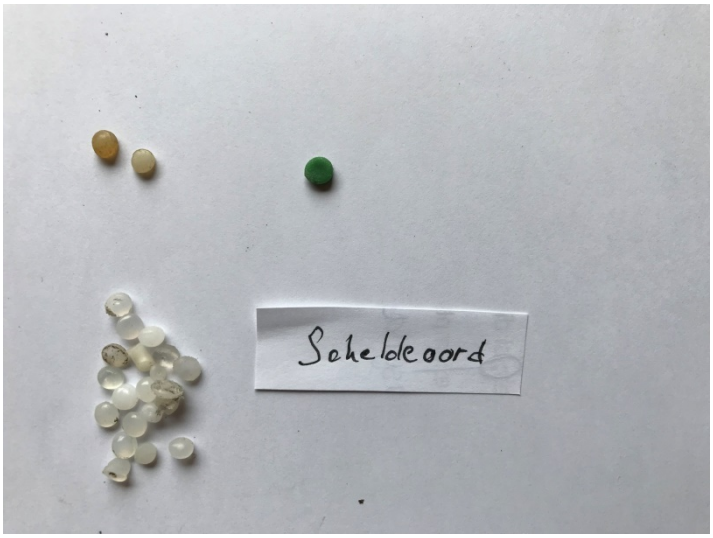
Coudorpe

location	
location	Ellewoutsdijk haventje
date	3-9-2021
coordinates	X=45690 ; Y=378591
number per m^1	20
length of deposit	100
surface total	2,000



Ellewoutsdijk haventje

location	
location	Scheldeoord
date	3-9-2021
coordinates	X=50988 ; Y=379404
number per m^1	1
length of deposit	200
surface total	200



Scheldeoord

location	
location	Hoedekenskerke haventje
date	3-9-2021
coordinates	X=52713 ; Y=382355
number per m^1	20
length of deposit	25
surface total	500

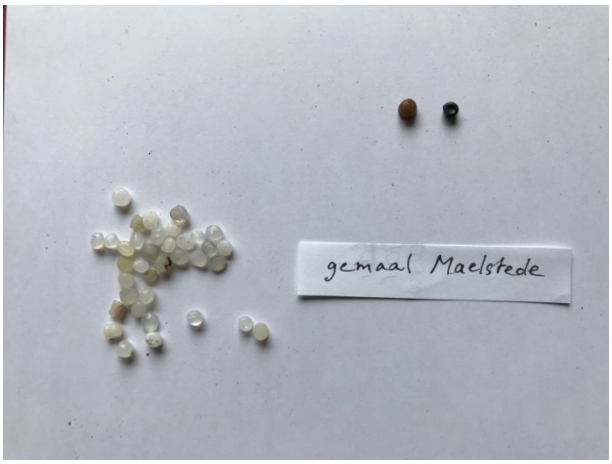
No picture taken

location	
location	Hoedekenskerke groyne
date	3-9-2021
coordinates	X=53357 ; Y=384236
number per m^1	0
length of deposit	
surface total	0

No picture taken

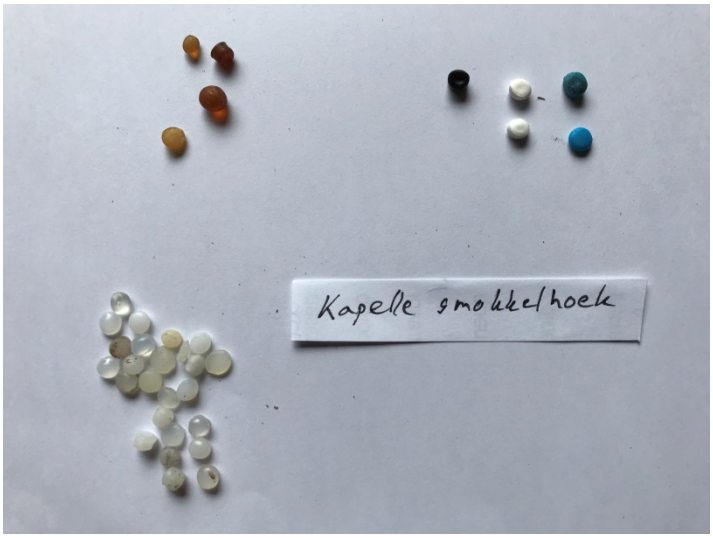
Location	
Location	Slabbekoornsedijk
Date	3-9-2021
Coordinates	X=53108 ; Y=384985
number per m^1	0
length of deposit	
surface total	0

location	
location	Gemaal Maelstede
date	3-9-2021
coordinates	X=53383 ; Y=385748
number per m^1	5
length of deposit	100
surface total	500



No picture taken

location	
location	Kapelle smokkelhoek
date	3-9-2021
coordinates	X=56947 ; Y=386874
number per m^1	10
length of deposit	100
surface total	1,000



Kapelle smokkelhoek

location	
location	Hansweert
date	3-9-2021
coordinates	X=58833 ; Y=384863
number per m^1	200
length of deposit	150
surface total	30,000

Hansweert

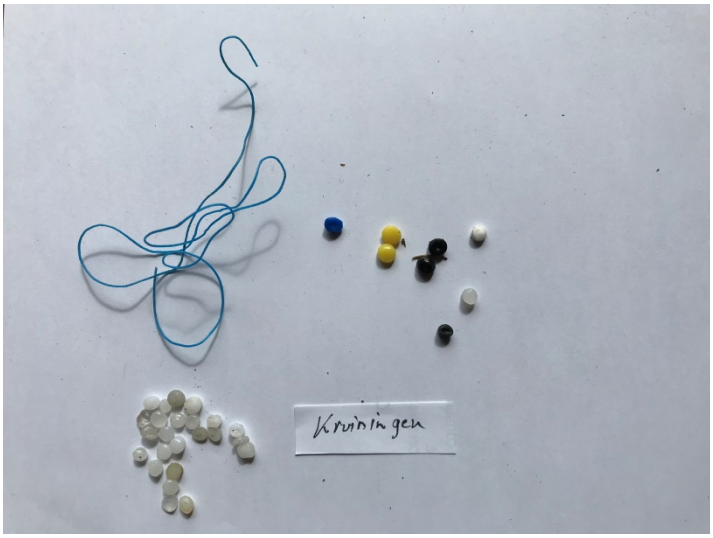
Hansweert zoom in

In more detail

In more detail

In more detail

location	
location	Kruiningen Vroondijk/Inkeldijk
date	3-9-2021
coordinates	X=62080 ; Y=383143
number per m^1	100
length of deposit	50
surface total	5,000



Nurdles Kruiningen: 'vispluis' (blue thread on picture) was found on all locations

Kruiningen: corner Vroondijk-Inkeldijk

location	
location	Bath berging spuisluis 2x
date	3-9-2021
coordinates	X=73601 ; Y=379570 X=73731 ; Y=379498
number per m^1	2 x 25 = 50
length of deposits	2 x 50 = 100 m
surface total	5,000

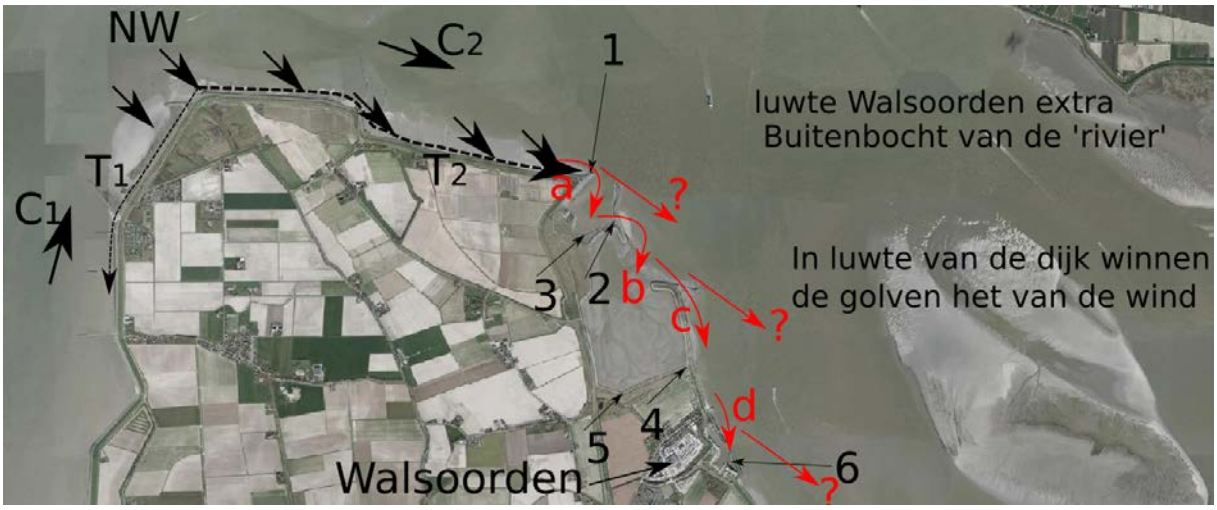
Bath berging spuisluis inside corner. Harbour of Antwerpen in the background

Annex III Bank transport Veerhaven Walsoorden

Start of the process is in the upper left corner of the picture with a storm coming from the northwest (NW). This results in two transport streams along the banks. T1 will be smaller than T2 because with the storm a strong tide current (C1) develops in the opposite direction. T2 will be stronger for the same reason because of C2.

At point 1 one expects the nurdles/debris to leave the shore and a part probably does (?). However another part flows into the Veerhaven. This must be due to the current directly behind the groyne/breakwater (a) which is directed into the harbour. The wind loses its grip there because the groyne breaks it and causes an underpressure directly behind the groyne (see further on).

The findings of the nurdles (1,2,3,4,5) are shown after the explanation. Finding 6 is in Annex II (nr 4).



Once in the harbour the wind regains its grip and transports the nurdles to the southeast corner (2).If the storm is strong enough and the water high enough the nurdles leave the harbour (b) over the breakwater/groyne (level NAP + 3,5 m).

SE-corner Veerhaven red arrow = b, black arrows are findings of nurdles

Part of the nurdles flow into the Perkpolder (b) and remain there because the dike level is at NAP + 8,5 m (findings 4 and 5). Another part flows over the groyne (level NAP + 3,5 m) and is transported along the bank (c). Another part of them might leave the shore (?).

Apparently the nurdles are transported along the bank from c to Walsoorden where a similar process takes place as with a and b.
Apparently because with the wind direction, being northwest, this wasn't expected.
This bank transport seems to be caused by 4 aspects:

1. outer bend of the Westerschelde (river);
2. underpressure behind the dike;
3. water displacement and waves caused by ships.
4. shoaling growing tide wave?

Ad 1. By centrifugal force the water is pushed towards the outer bend. This applies both for rising and falling water. The effect is larger in a situation with high current velocities like with northwest storms and rising water.
Ad 2. If the wind is blowing from a direction perpendicular to the dike there will be overpressure on the windward side and underpressure on the leeward side (lit. nr? Plaisier, A. et al; Windklimaat in de gebouwde omgeving, 2016 PAO SKB).
With westerly winds an easterly wind stream will develop behind the dike to fill up this underpressure.

Flat calm behind the dike at Perkpolder with WSW 3 Bft

Ad 3. With rising tide and westerly wind this effect was visually measured with some organic debris thrown into the waterline, just behind the weed, that was followed for half an hour.

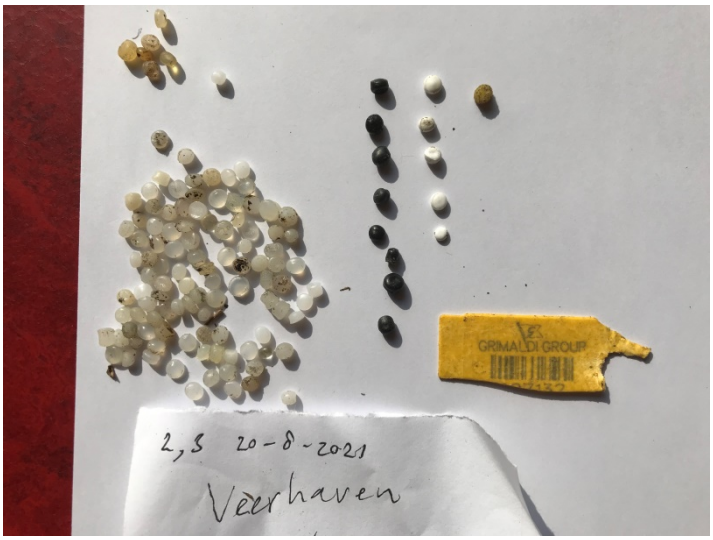
Container vessel coming from Antwerpen at the height of Perkpolder

Especially with the water displacement caused by the ships coming from Antwerpen the debris travelled further in the direction of Walsoorden than it did in the reversed way. After half an hour and 4 ships it had covered a distance of about 30 m.
The ship waves coming in from the Antwerpen direction (angle ~37)don't make a big difference in the water itself. Only at the waterline transport of weed is visible.
Ad 4. The above 3 observations and assumptions are described qualitatively. If desired they can be measured relatively easy with existing techniques.
That shoaling could play a role is an assumption based on the fact that the tidal flood wave will grow if the narrowing of the water body is gradually. The relatively large tidal range in the Westerschelde is caused by this phenomenon. Because the waterlevel rises quicker this might cause transport along the banks higher than expected.

Annex IIIA Deposits Veerhaven-Walsoorden

location	1
location	VeerhavenNO-pier/ Bar Goed
date	20-8-2021
coordinates	X=59756 ; Y=380004
number per m^1	10
length of deposit	25
surface total	250

location	2
location	Veerhaven ZO-hoek
date	20-8-2021
coordinates	X=59991 ; Y=379642
number per m^1	200
length of deposit	50
surface total	10,000



Nurdles idem 3


SE-corner Veerhaven

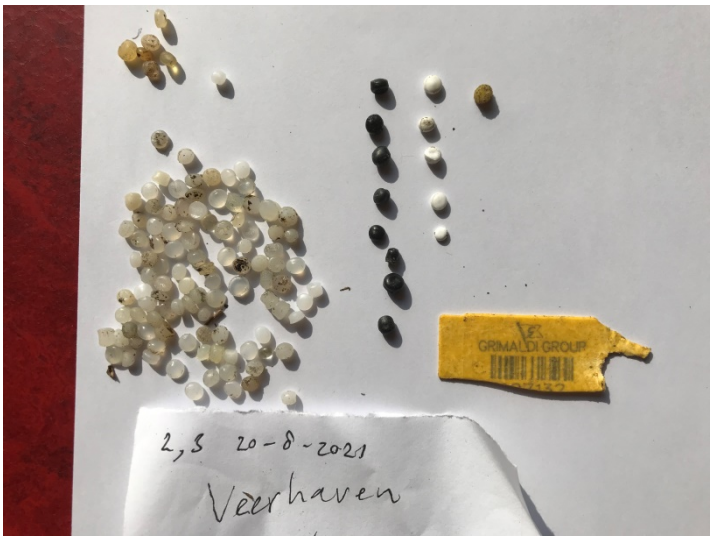
Next picture in more detail

SE-corner Veerhaven (2) the white spiccles on the organic (brown) debris are nurdles

Next picture in more detail

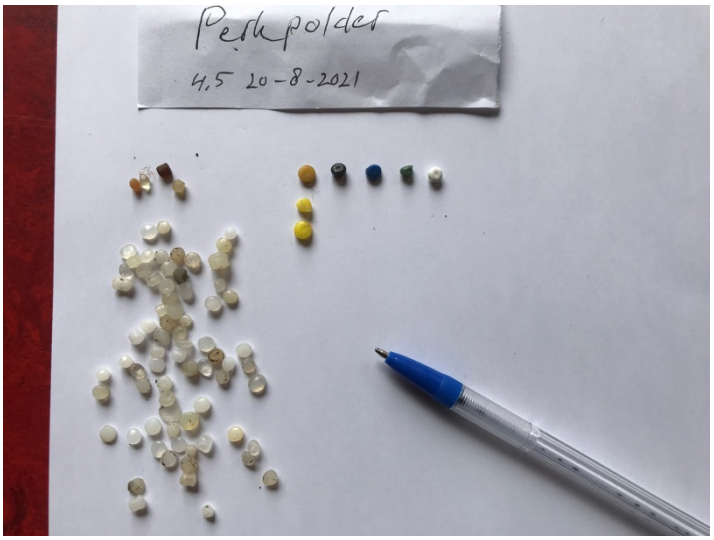
Next picture in more detail

location	3
location	Veerhaven ZW-hoek
date	20-8-2021
coordinates	X=59753 ; Y=379541
number per m^1	100
length of deposit	50
surface total	5,000



Nurdles idem2

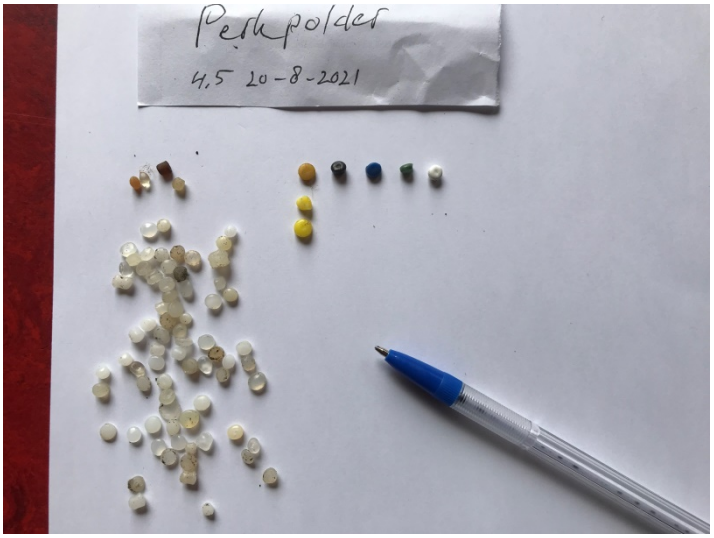
location	4
location	Perkpolder ZO-hoek
date	20-8-2021
coordinates	X=60554 ; Y=378525
number per m^1	10
length of deposit	50
surface total	250



Nurdles idem 5


Perkpolder SE-corner

location	5
location	Perkpolder ZW-hoek
date	20-8-2021
coordinates	X=60046 ; Y=378296
number per m^1	5
length of deposit	25
surface total	125



Nurdles idem 4


Perkpolder SW-cormer

Annex IV Deposits Antwerpen Schelde

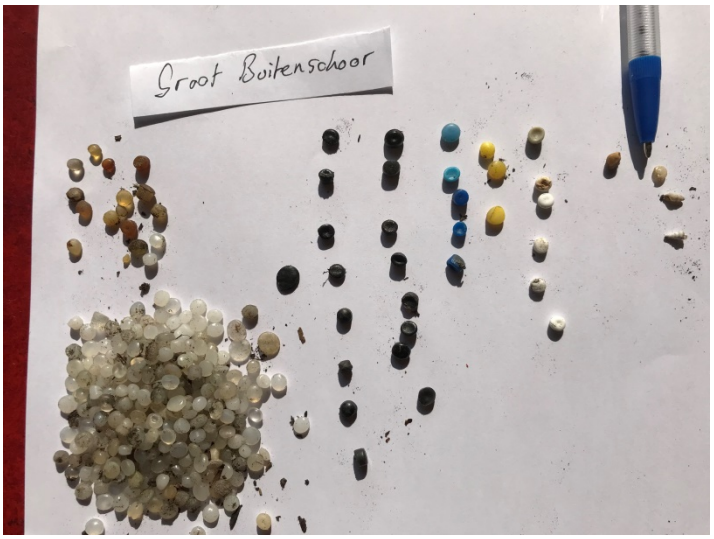
location	
location	Grensweg ZO-hoek
date	17-9-2021
Coordinates (google maps)	X=51.37976 ; Y=4.24575
number per m^1	100
length of deposits	200
surface total	20,000

Multicolour. The brownish on the right (17) are plant seeds, the white on the right (2) are small shells

location	
location	Rijn-Scheldekanaal SE-corner
date	17-9-2021
Coordinates (google maps)	X=51.37375 ; Y=4.30374 Floats around!
number per m^1	Floating mass
length of deposits	-
surface total	10,000

Multicolour. Relatively large amount of UV-nurdles (brown/yellow in upper left corner). Many of the nurdles are degraded: they have been floating around for years.

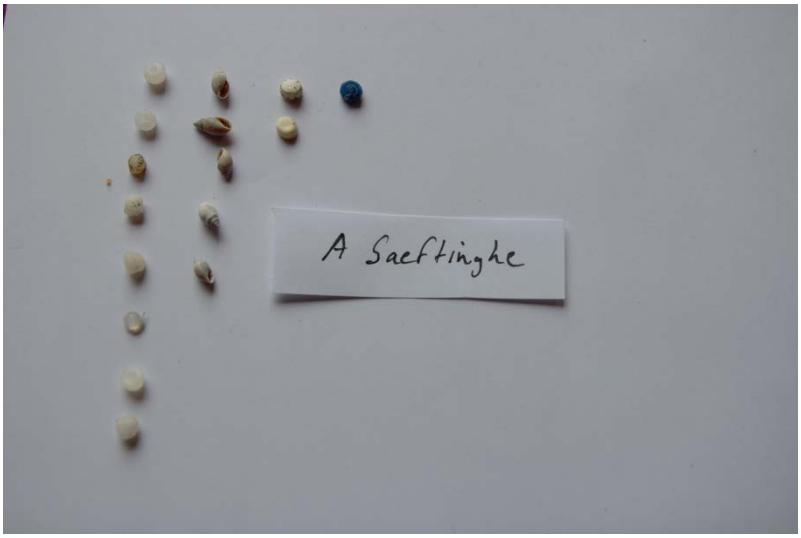
location	
location	Buitenschoor/PSA kaai 193
date	17-9-2021
Coordinates (google maps)	X=51.35571 ; Y=4.25395
number per m^1	500
length of deposits	600
surface total	300,000



Upper right, indicated by the pen, 3 shells (right), 1 plant seed

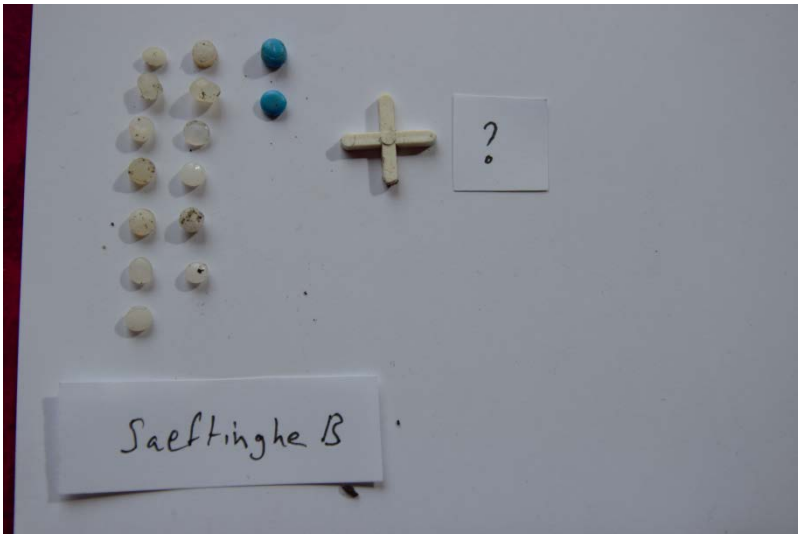
location	
location	Saeftinghe nul
date	24-9-2021
Coordinates (google maps)	X=69710 ; Y=371695
number per m^1	0
length of deposits	-
surface total	0

location	
location	Saeftinghe A
date	24-9-2021
Coordinates (google maps)	X=71076 ; Y=372199
number per m^1	2
length of deposits	100
surface total	200



Second column are little shells as a comparison

location	
location	Saeftinghe B
date	24-9-2021
Coordinates (google maps)	X=71340 ; Y=372654
number per m^1	10
length of deposits	100
surface total	1,000



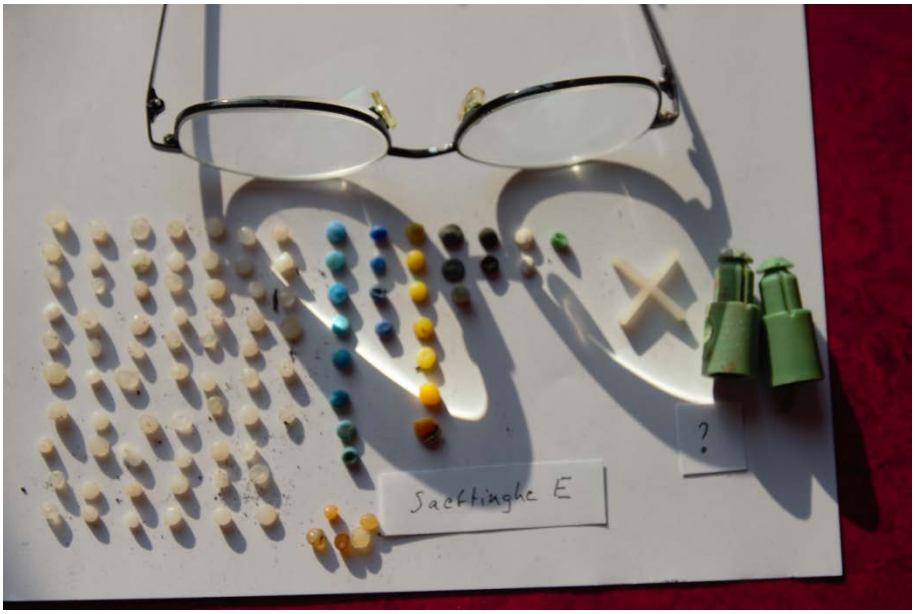
location	
location	Saeftinghe C
date	24-9-2021
Coordinates (google maps)	X=72111 ; Y=373341
number per m^1	2
length of deposits	100
surface total	200

The flat nurdle indicated by the pen was run over by a tire without air/ high surface pressure like a forklift.

location	
location	Saeftinghe D
date	24-9-2021
Coordinates (google maps)	X=72924 ; Y=374073
number per m^1	100
length of deposits	100
surface total	10,000

The crosses are used as spacers between terrace tiles and transported in big quantities (like nurdles) as a bulk good or in big bags.

location	
location	Saeftinghe E
date	24-9-2021
Coordinates (google maps)	X=73431 ; Y=374601
number per m^1	100
length of deposits	200
surface total	20,000



If you need reading glasses you can't find them without

location	
location	Schelde oostoever Saeftinghe F
date	24-9-2021
Coordinates (google maps)	X=73726 ; Y=375064
number per m^1	500
length of deposits	100
surface total	50,000

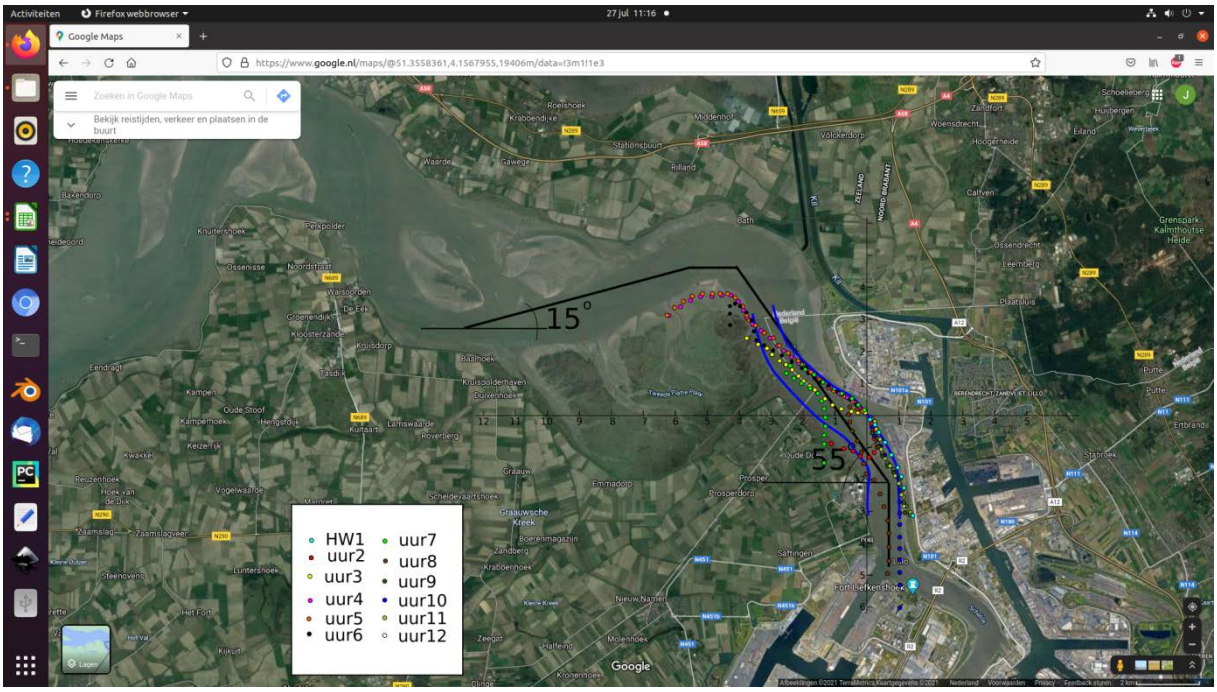
Unusual shapes like the comma-form of the nurdles in the right column might give the information needed to trace them back to the producer

Vision on the sluices: PSAkaai913 on the left and cooling towers of Doel on the right

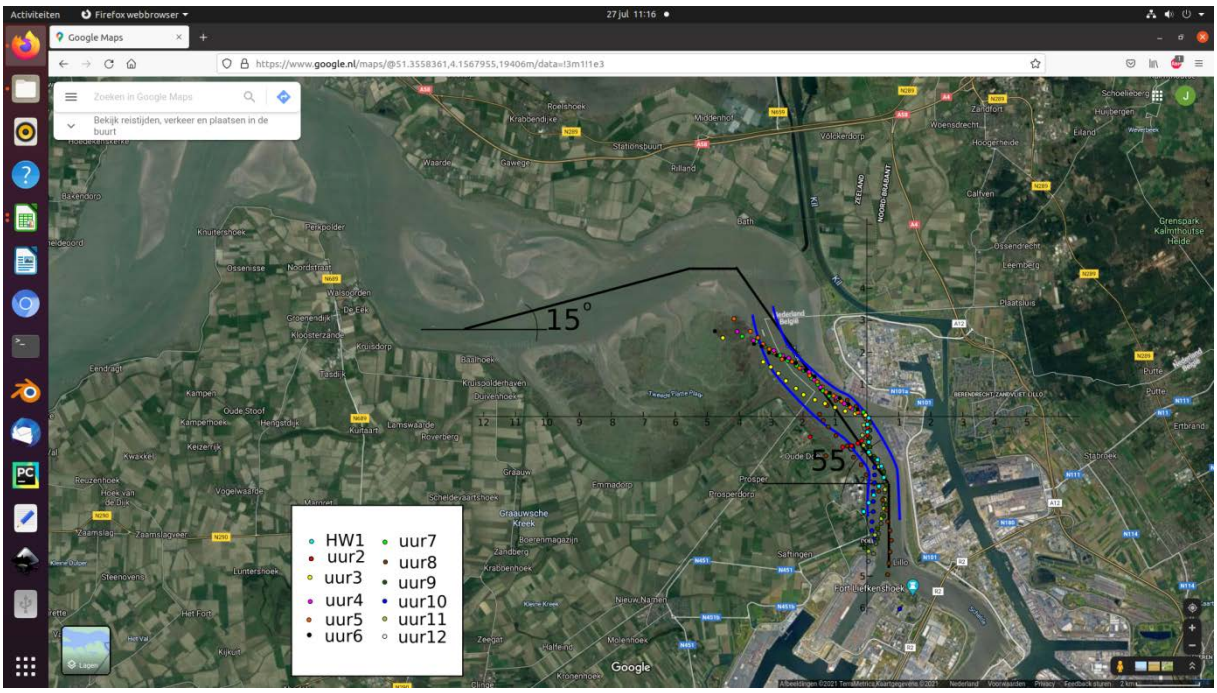
In more detail

In more detail

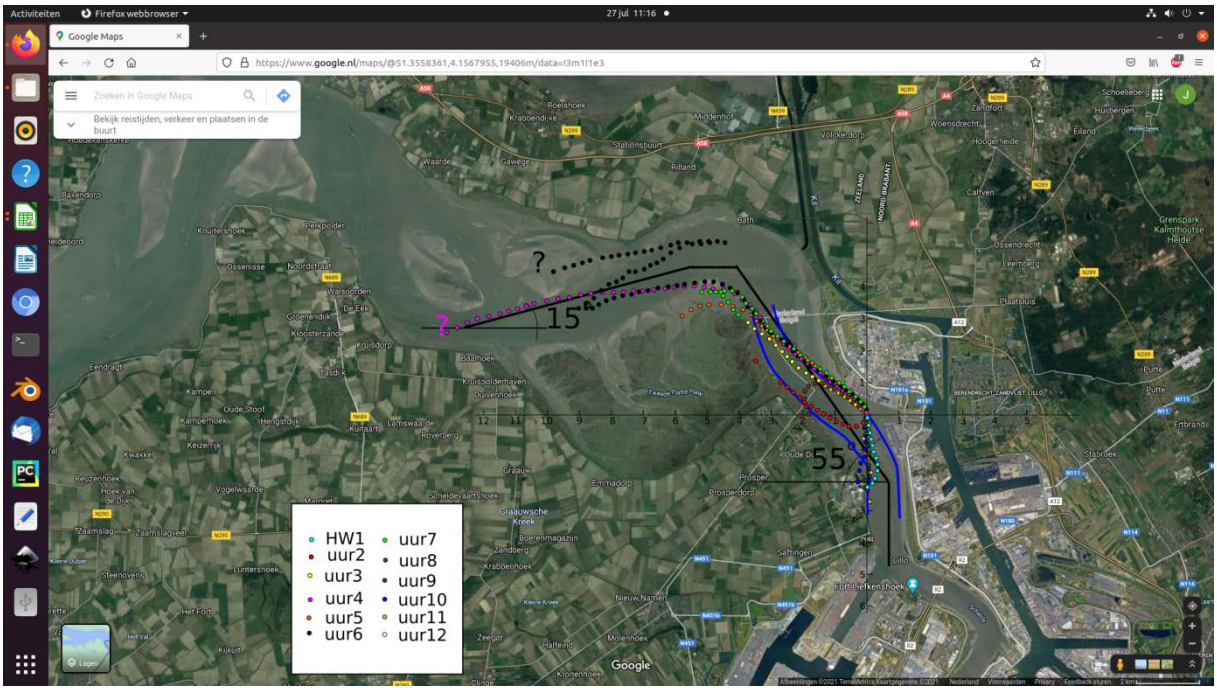
Annex IV A Antwerpen spreading of ‘sluice’ nurdles



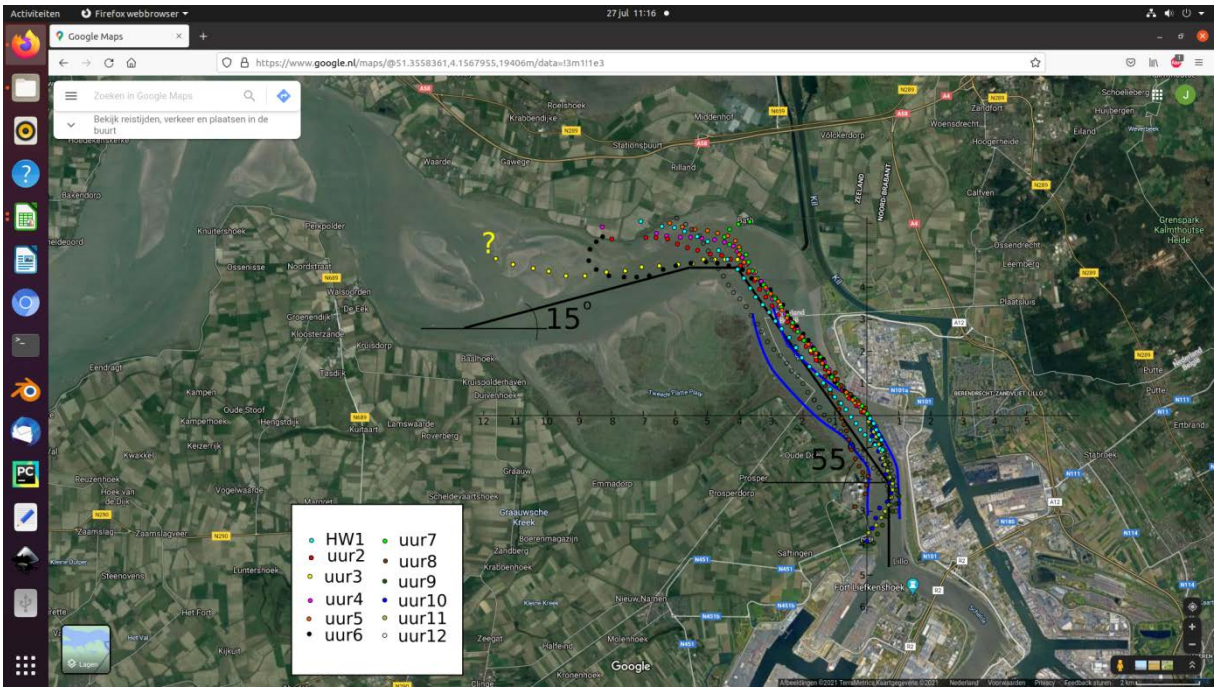
Wind from the north



North east

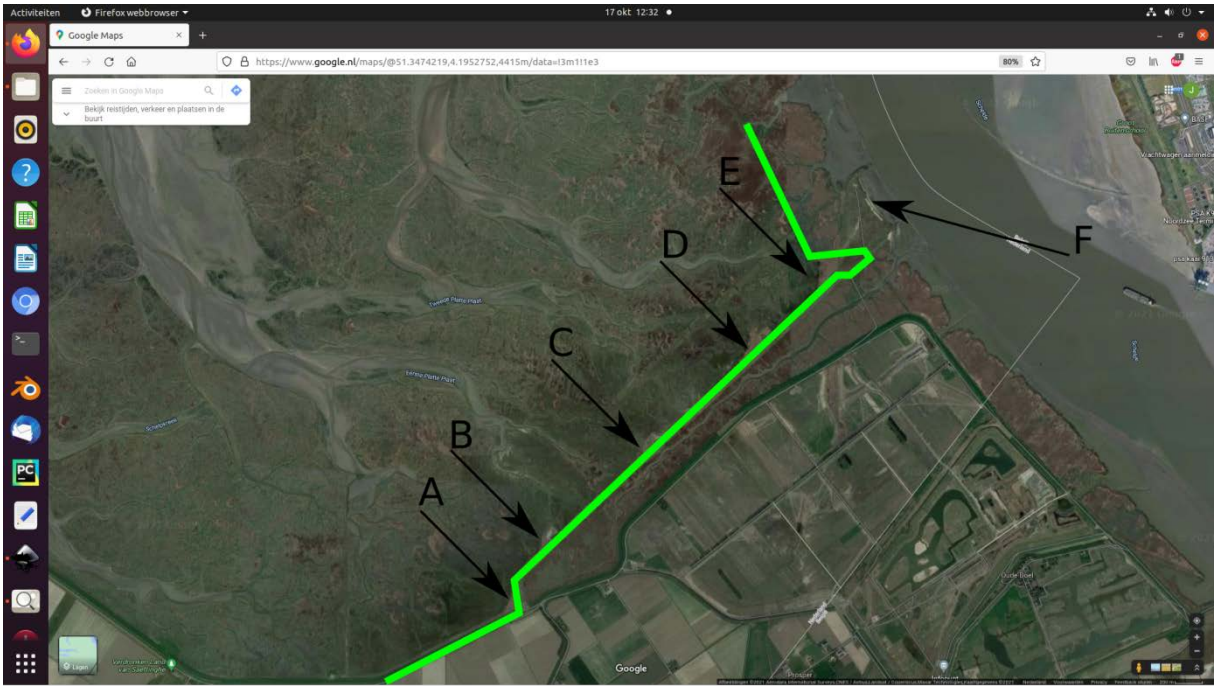


East

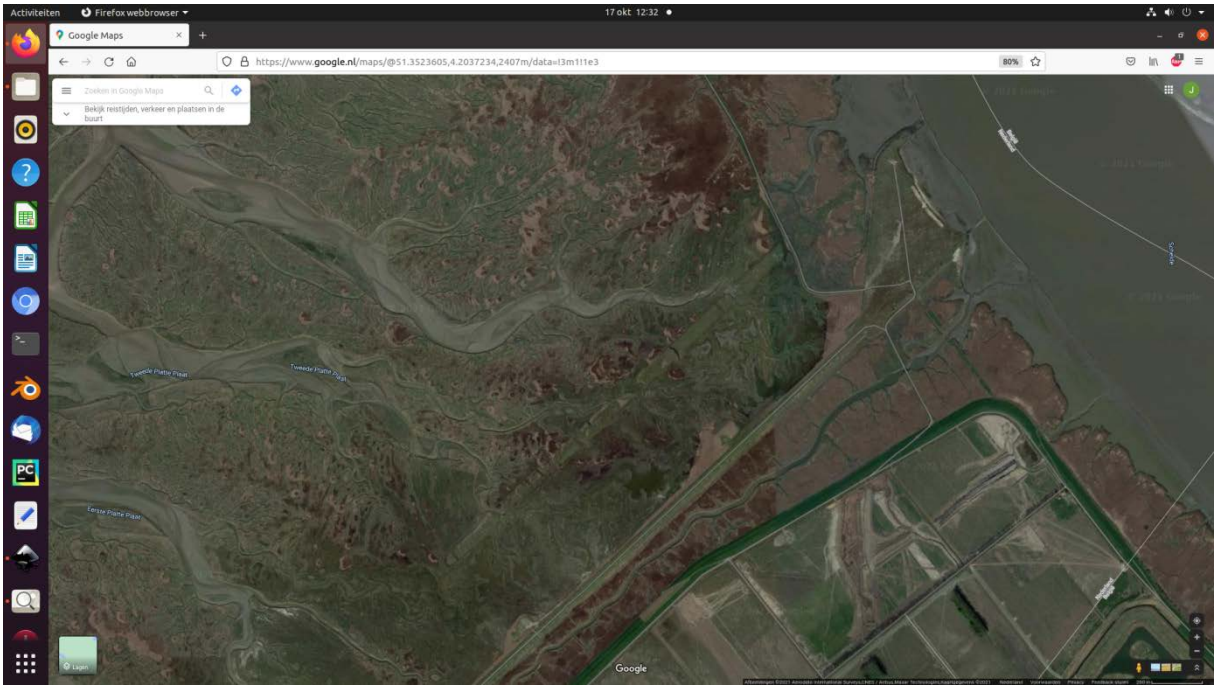


South east

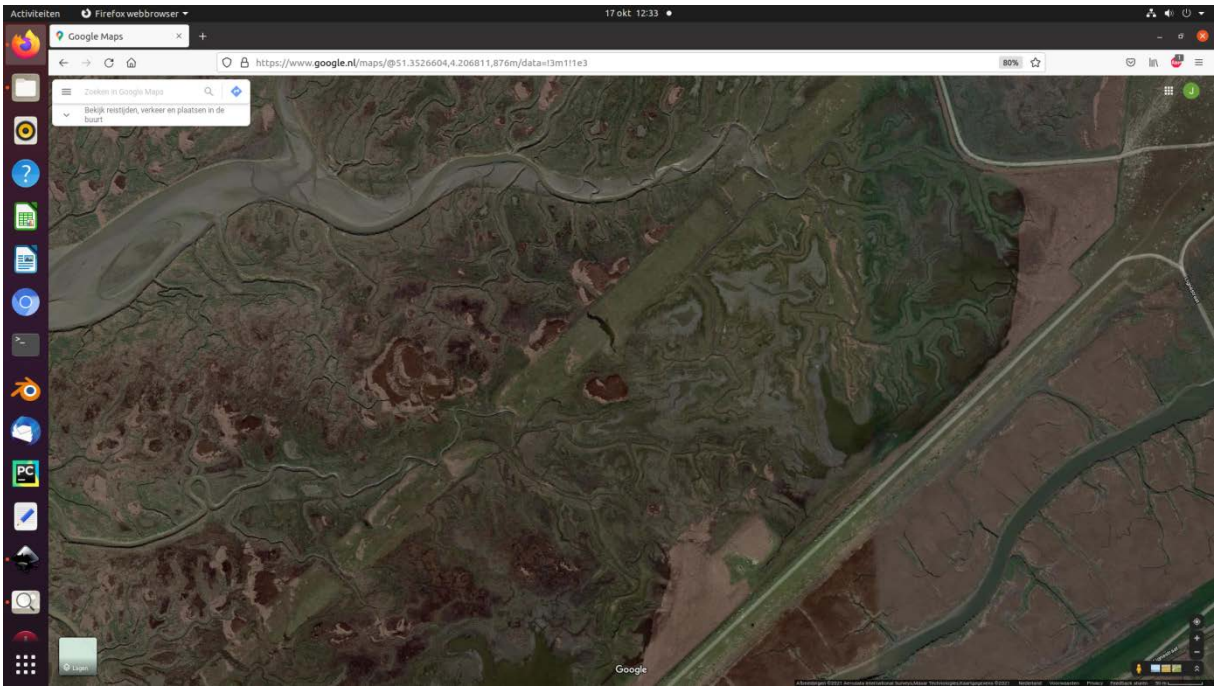
Annex IV B Deposits Antwerpen > Saeftinge



Deposits of nurdles in Saeftinghe



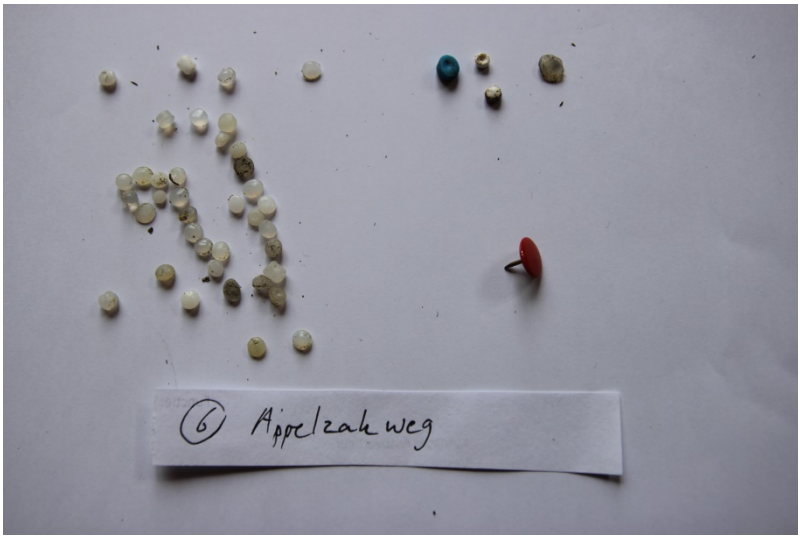
Deposits C, D and E more closely. Nurdles have similar floating behaviour as small organic debris. They are found together in the brown triangles



Deposit D and E more closely. The aerial photo (Google Maps) must have been taken at the end of a winter in which a recent north west storm occurred because vegetation is brownish and the debris triangles are clearly demarcated.

Annex V Deposits North Sea Westerschelde

location	6
location	Appelzakweg
date	9-8-2021
coordinates	X=38293 ; Y=375252
number per m^1	10
length of deposit	?
surface total	?



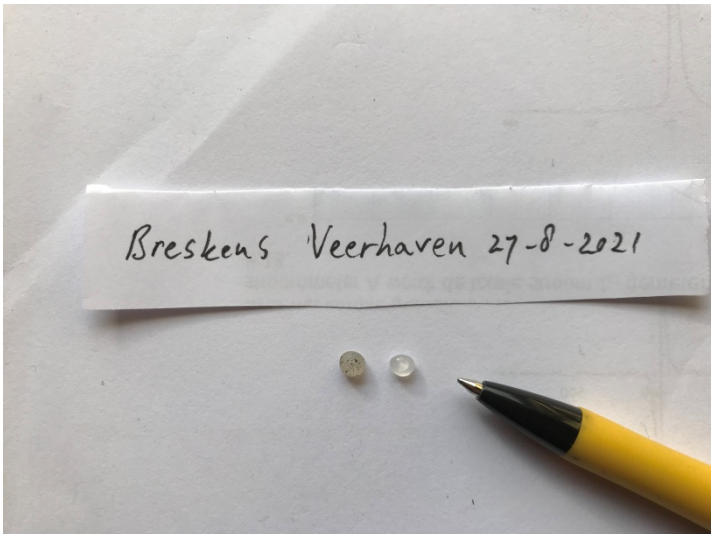
location	7
location	GemaalZN Plaskreek
date	9-8-2021
coordinates	X=36882 ; Y=376553
number per m^1	10
length of deposit	25
surface total	250

The Victor Horta is a hopper dredger of DEME-group

location	8
location	Breskens oostrand gemaal
date	9-8-2021
coordinates	X=30499 ; Y=378894
number per m^1	10
length of deposit	50
surface total	500

NDQ (seal) is an international trailer operator based in Zeebrugge. It provides road transport in Europe and especially to and from the United Kingdom.

location	
location	Breskens Veerhaven
date	27-8-2021
coordinates	X=27237 ; Y=380683
number per m^1	-
length of deposit	-
surface total	2



location	
location	Breskens strand
date	27-8-2021
coordinates	X=28141 ; Y=380421
number per m^1	25
length of deposit	200
surface total	5,000

The nurdle indicated by the pen is a Bio Bead

Detail of the spread under the vegetation

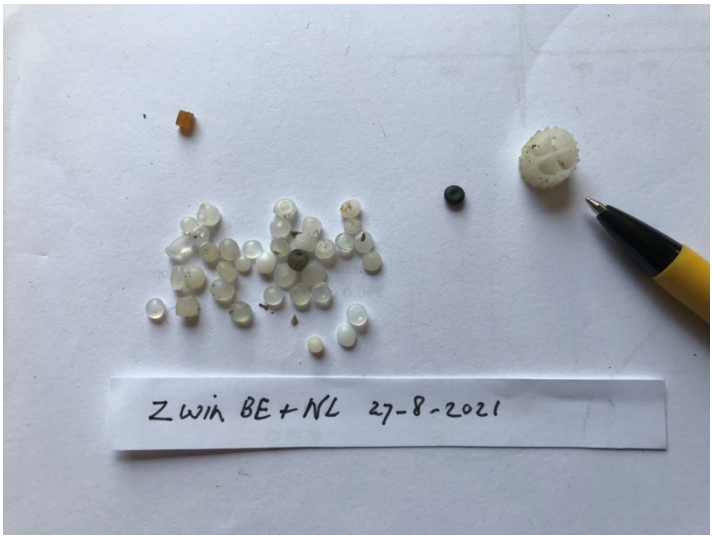
A volunteer is collecting nurdles at Breskens strand (in the background Vlissingen)

location	
location	Roompot strand
date	27-8-2021
coordinates	X=26952 ; Y=381157
number per m^1	100
length of deposit	500
surface total	50,000

The nurdles indicated by the pen are Bio Beads (26). They are, in general, bigger and more degraded than 'normal' nurdles. Bio beads are used in sewage water treatment plants in the UK.

Nurdles were found in the red band on the highest, dry, part of the beach, over a width of about 3 m

location	
location	Zwin BE + NL
date	27-8-2021
coordinates	BE X=14397 ; Y=374780 NL X=14989 ; Y=375253
number per m^1	5
length of deposit	50
surface total	250

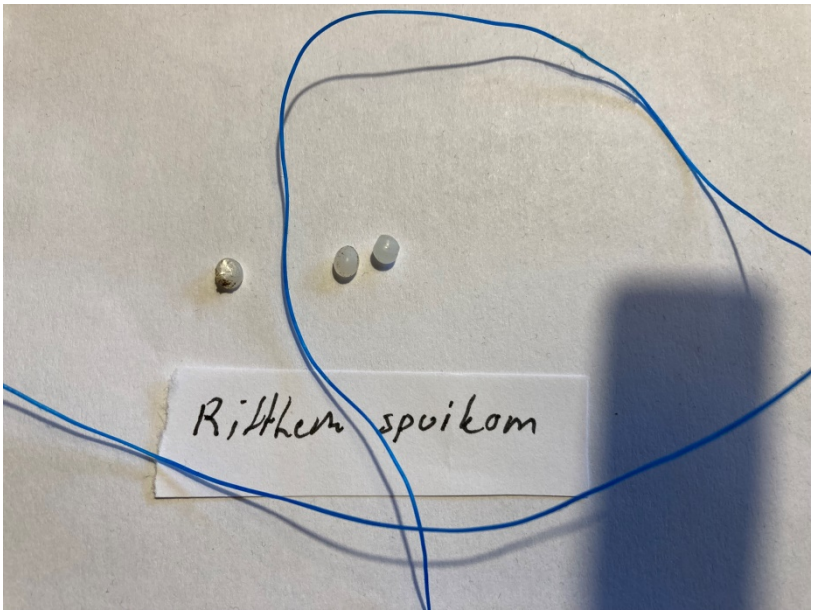


The object indicated by the pen is a plastic wheelshaped bio medium commonly used in wastewater treatment in the UK (lit 4 Wallerstein, C)

Zwin: Corner west (4 NL). The nurdles were found where the bridge meets the bank

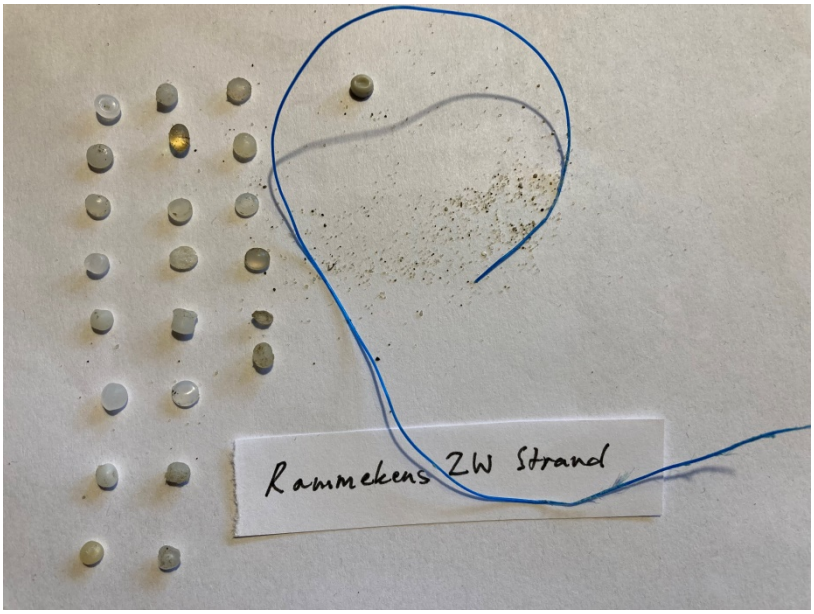
Annex Va Deposits North Sea Vlissingen

location	
location	Ritthem spuikom
date	05-11-2021
Coordinates	X=32370 ; Y=385069
number per m^1	-
length of deposits	-
surface total	3



No picture taken on location

location	
location	Rammekens ZW strand
date	05-11-2021
Coordinates	X=33899 ; Y=385954
number per m^1	low
length of deposits	-
surface total	100



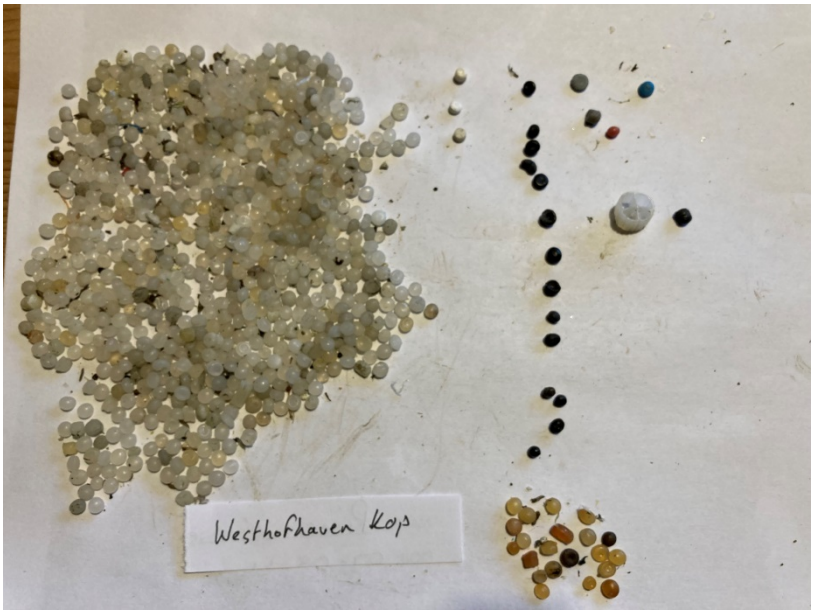
location	
location	Rammekens strekdam strand
date	05-11-2021
Coordinates	X=34874 ; Y=386208
number per m^1	5
length of deposits	200
surface total	1,000

The 3 flat nurdles indicated by the pencil were run over

location	
location	Rammekens strekdam hoek
date	05-11-2021
Coordinates	X=35438 ; Y=385912
number per m^1	corner
length of deposits	-
surface total	5,000

The black nurdles in the right column are Bio Beads. Down right are grains for aquaculture.

location	
location	Kop Westhofhaven
date	05-11-2021
Coordinates	X=39279 ; Y=388460
number per m^1	5,000
length of deposits	200
surface total	1,000,000



1 Bio Bead, 1 bio medium

Location	
Location	Kaloot
date	05-11-2021
Coordinates	X=38566 ; Y=383847
number per m^1	20 + corner
length of deposits	200 + corner outlet
surface total	10,000

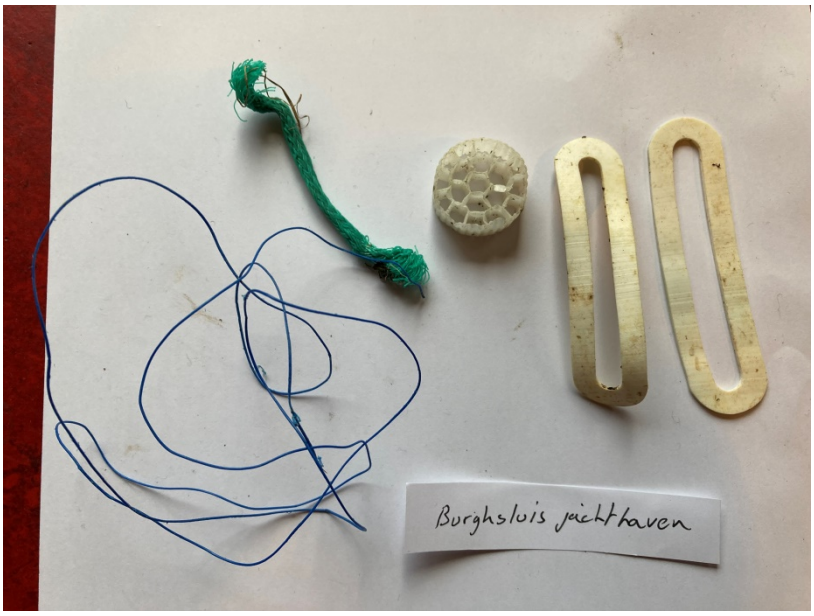
The 7 balls on the right are used to blow through (clean) the water pipes of power plants.

Outlet (right) power plant EPZ Borssele . Could be the source for the balls. Sloecentrale is another power plant.

Annex V b Deposits North Sea Oosterschelde

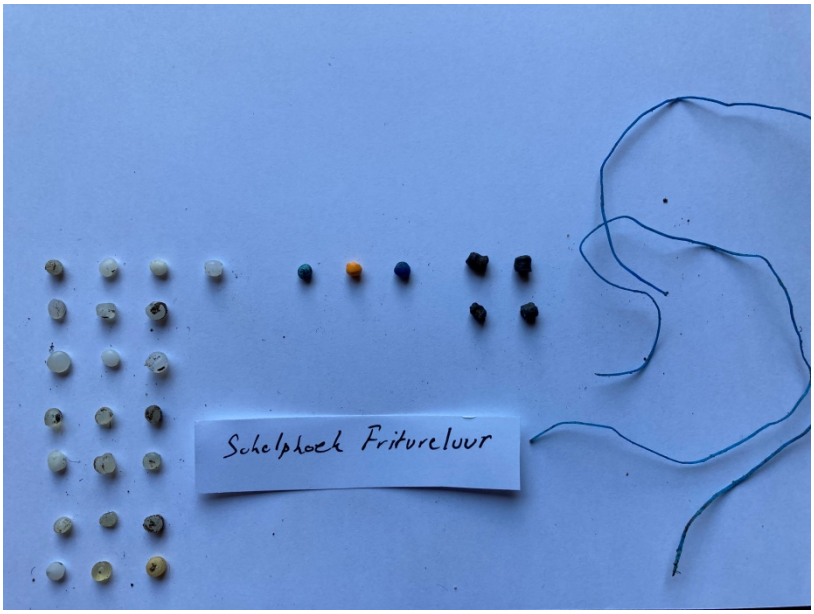
Location	O1
location	Burghsluis West buiten
date	19-10-2021
Coordinates	X=42057 ; Y=410686
number per m^1	0
length of deposits	-
surface total	0

location	O2
location	Burghsluis haven binnen
date	19-10-2021
Coordinates	X=42359 ; Y=411032
number per m^1	0
length of deposits	-
surface total	0



No nurdles. On every location: plastic from ‘the fisheries’.

location	O3
location	Schelphoek Fritureluur
date	19-10-2021
Coordinates	X=46169 ; Y=413286
number per m^1	10
length of deposits	10
surface total	100



Upper right 4 Bio Beads

Nurdles allways come together with other plastics

location	O4/5
location	Schelphoek ZO-hoeken (2)
date	19-10-2021
Coordinates	X=47012 ; Y=412098 X=46866 ; Y=411761
number per m^1	100
length of deposits	100 + corner
surface total	10,000 + 10,000

The upper two rows are Bio Media used in water purification. According to ‘omroep Zeeland’ the upper row (black) originate from Kingfish at Colijnsplaat https://www.omroepzeeland.nl/nieuws/126966/Plastic-filters-Oosterschelde-inderdaad-van-Kingfish-Zeeland

The pencil points at what seem to be blue and grey Bio Beads. Above the pencil ‘normal’ black Bio Beads. Downright 3 BB-gun balls (ammunition of a children’s toy).

Detail Schelphoek: nurdles south east corners

location	O6
location	Kerkerwe Heerenkeet
date	19-10-2021
Coordinates	X=49235 ; Y=411039
number per m^1	0
length of deposits	-
surface total	0

location	O7
location	Kerkerwe Oosthoek
date	19-10-2021
Coordinates	X=48702 ; Y=410931
number per m^1	-
length of deposits	corner
surface total	10,000

Detail Kerkerwe 19-10-2021: This location was cleaned up thoroughly in December 2020.

https://www.omroepzeeland.nl/nieuws/124065/Vrijwilligers-ruimen-aangespoelde-plastic-korrels-op-met-zelfontworpen-apparaat

location	O8
location	Kisters Inlaag P
date	19-10-2021
Coordinates	X=51062 ; Y=408577
number per m^1	0
length of deposits	-
surface total	0

No picture taken

location	O9
location	Cauwers Inlaag NW-hoek
date	19-10-2021
Coordinates	X=51124 ; Y=407712
number per m^1	100
length of deposits	50
surface total	5,000

On the left found at all locations: plastic from the fisheries.

Upper right two rows, bio media for water purification. Polluting water with water purification is an anomaly.

Cauwers Inlaag NW-corner

location	O10
location	Havenhoofd Zierikzee Noord
date	20-10-2021
Coordinates	X=51929 ; Y=406380
number per m^1	0
length of deposits	-
surface total	0

location	O11
location	Zierikzee de Val
date	20-10-2021
Coordinates	X=53842 ; Y=405630
number per m^1	-
length of deposits	Corner
surface total	50,000

At the right: ‘the fisheries’

In the middle: water pollution/purification. The pencil is points towards blue/gray Bio Beads. In comparison with the Westerschelde the number of Bio Beads is large and is ‘deeper’ in the estuary.

Zierikzee de Val in the background the Zeelandbrug

This is one of the hot spots. With the prevailing wind from the south west (picture was taken with south west wind) transport along the bank is from both sides into this corner. With north west storms the debris (and nurdles) will float to the south east corner but can’t escape.

The configuration is very similar to the cove at Kerkerwe oosthoek and Schelphoek.

location	O12
location	Stille Strand W-hoek
date	20-10-2021
Coordinates	X=54509 ; Y=406249
number per m^1	0
length of deposits	-
surface total	0

Stille Strand W-hoek: no nurdles, the orange basket is from ‘the fisheries’

location	O13
location	Stille Strand O-hoek
date	20-10-2021
Coordinates	X=54781 ; Y=406109
number per m^1	50
length of deposits	50
surface total	2,500

Upper right the rubber (plastic/ elastic) bands are used by Lenger Seafoods (the fisheries) for tying together razor clams(mesheften).
https://www.omroepzeeland.nl/nieuws/126231/Bedrijf-geeft-lozen-van-witte-elastieken-in-Oosterschelde-toe-Dit-is-zeer-confronterend
Down right: bio media.

Stille Strand east corner

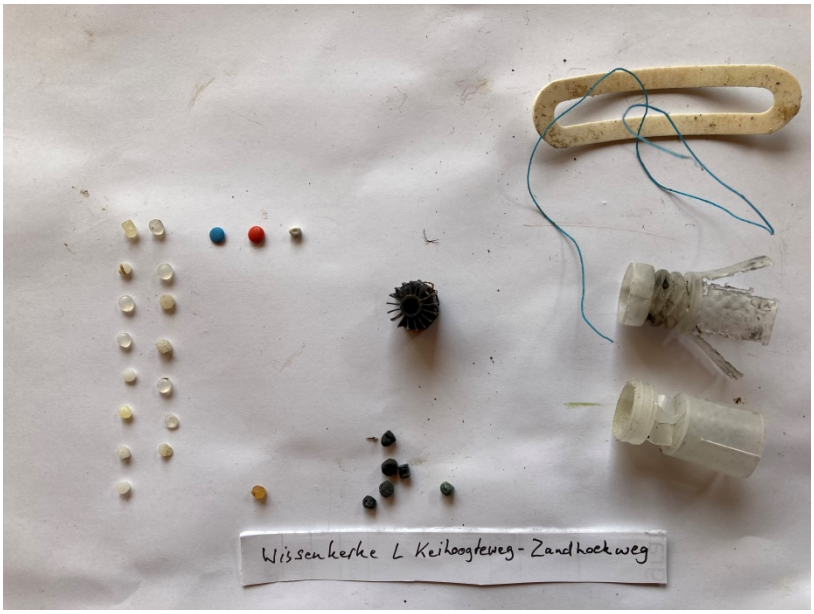
location	O14
location	Duikplaats Noordbout
date	20-10-2021
Coordinates	X=55264 ; Y=405019
number per m^1	0
length of deposits	-
surface total	0

No picture taken

location	O15
location	Kats noordkant
date	20-10-2021
Coordinates	X=51253 ; Y=399481
number per m^1	10
length of deposits	50
surface total	500

Kingfish is at a distance of 2,5 km of Kats

location	O16
location	Wissenkerke Keihoogteweg/ Zandhoekweg
date	20-10-2021
Coordinates	X=43351 ; Y=402158
number per m^1	10
length of deposits	50
surface total	500



location	O17
location	Roompot Sophiahaven binnen
date	20-10-2021
Coordinates	X=39516 ; Y=401654
number per m^1	-
length of deposits	Corner
surface total	100

No picture taken

location	O18
location	Roompot Sophiahaven buiten
date	20-10-2021
Coordinates	X=39012 ; Y=401999
number per m^1	0
length of deposits	-
surface total	0

No picture taken

location	O19
location	Wemeldinge strandje
date	21-10-2021
Coordinates	X=58914 ; Y=393412
number per m^1	10
length of deposits	20
surface total	200

location	O20
location	Yerseke strand
date	21-10-2021
Coordinates	X=61852 ; Y=391200
number per m^1	0
length of deposits	-
surface total	0

A rainy day at Yerseke

location	O21
location	Stavenisse Strand
date	21-10-2021
Coordinates	X=59206 ; Y=401447
number per m^1	10
length of deposits	100
surface total	1,000

location	O24
location	Banjaard Slufter
date	05-11-2021
Coordinates	X= ; Y=
number per m^1	20
length of deposits	100
surface total	2,000

The fisheries cause a lot of plastic pollution. 56 Bio Beads.

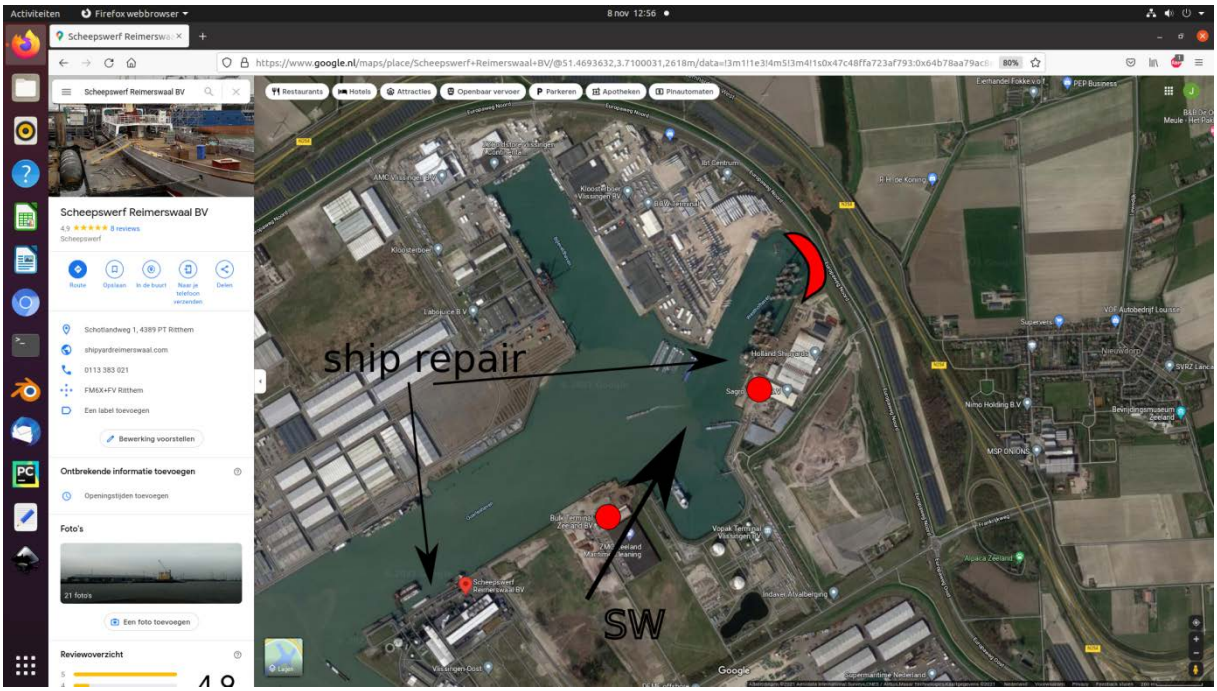
Location	O22/23
Location	Oesterdam ZO-hoek
Date	10-08-2021
Coordinates	X=73640 ; Y=385343 X=73835 ; Y=383576
number per m^1	0
length of deposits	-
surface total	0

No picture taken

Annex VI Westhofhaven hotspot

Introduction

The plastic hot spot in the west corner of the Westhofhaven cannot be explained with nurdles floating in from the North Sea. The source must be inside the port.



Deposits

Not only the number of nurdles is high but also the piles of ‘vispluis’ and other plastic are considerate.

Bank of the Westhofhaven transferred into a dump

When fishermen have their ships repaired at the quay they make use of this interval to repair the nets. Worn out 'vispluis' is replaced as well as the bad parts of the net. Obviously it is gut use to dispose of this plastic garbage by throwing it into the water. Problem solved. For the fishermen.

Wind and watersystem

Tidal current is negligible here at the end of the port. Prevailing wind blows into this corner. With easterly winds part of the plastic might float to the west but the chance that it leaves this corner of the Westhofhaven is very small. This can also be deduced by the nature of the plastics floating around here. Hereafter a serie of 4 pictures to illustrate this observation.

Sources

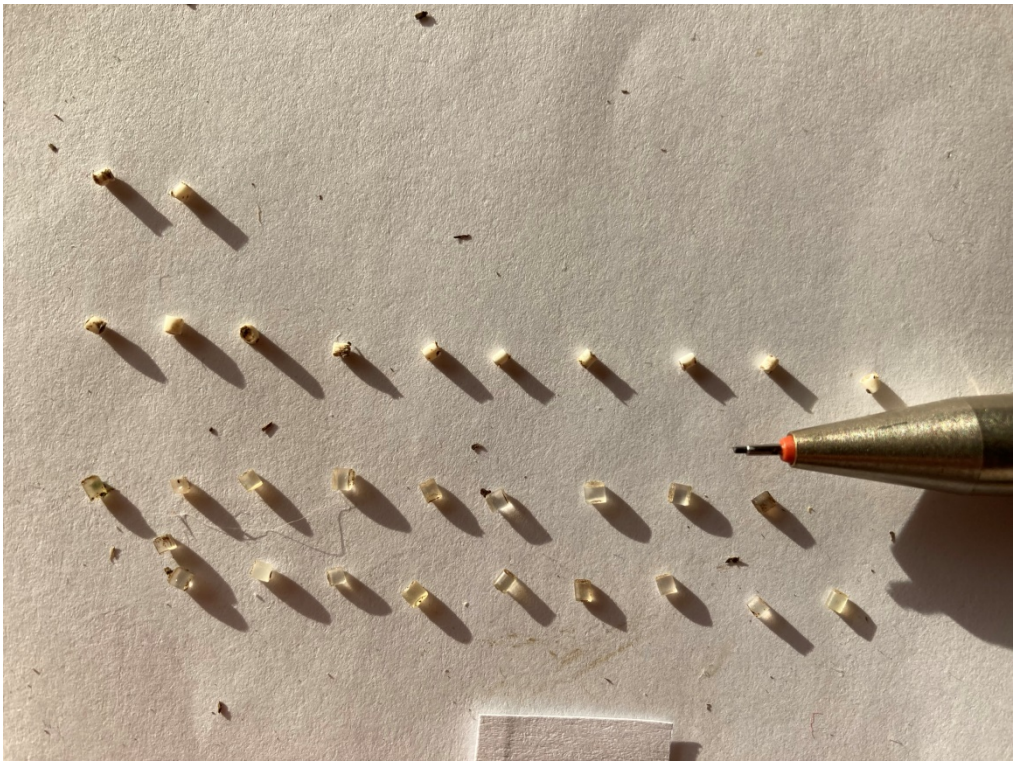
Even though there is a production site of Arkema in this port it is not likely that these nurdles came from there. Arkema produces polyamide which is a little heavier than water so they sink.

In the first Illustration the most likely sources are illustrated:
For the fisheries these might be the ship repair companies and for the nurdles the companies that are specialized in handling bulk goods indicated by the two red dots

Annex VII, Kanaal Gent terneuzen

location	GT1
location	Moerkaaivaart
date	12-11-2021
Coordinates (Google Maps)	X=51.13639 ; Y=3.79358
number per m^1	100
length of deposits	10
surface total	1,000

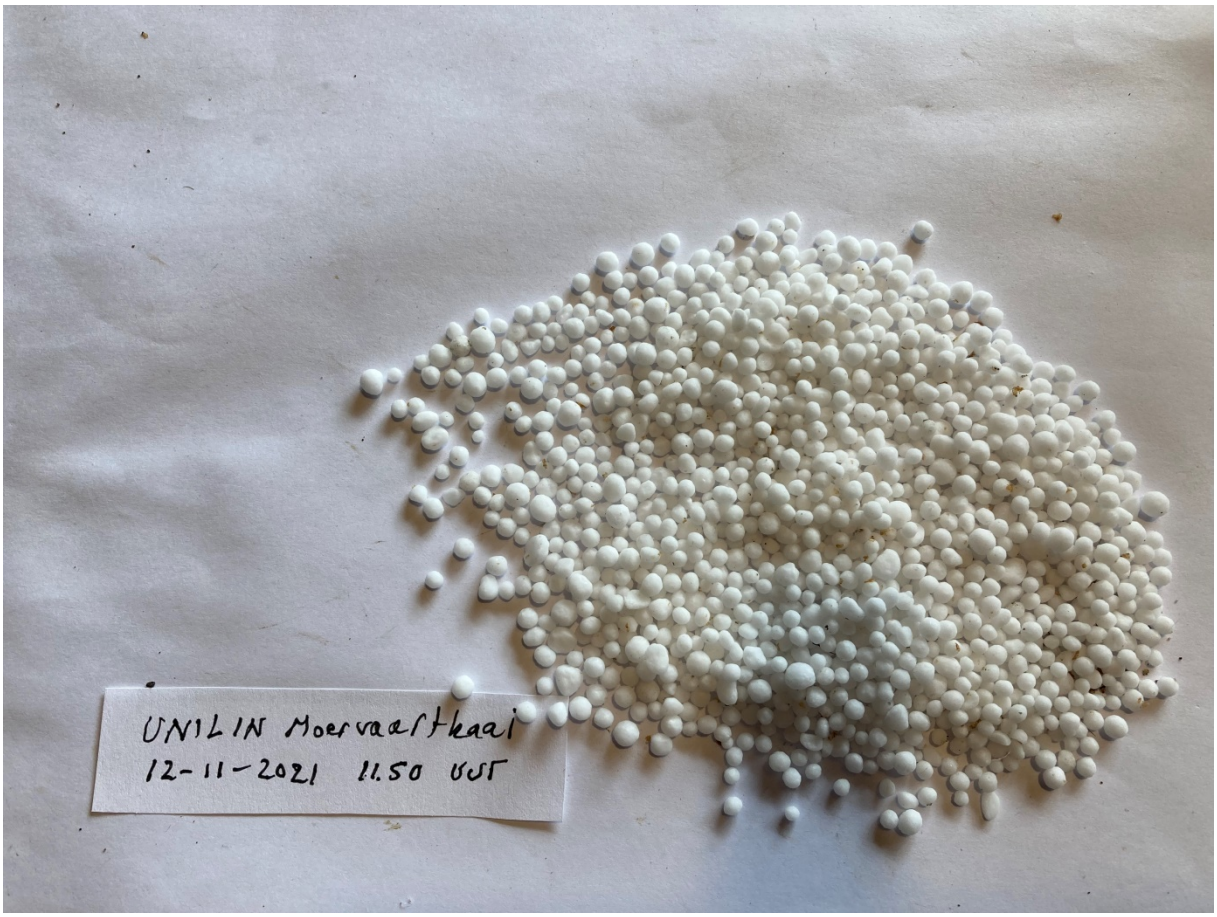
On the left of the pencil(0,5 mm)transparent nurdles?, on the right white



Transparent and white mini nurdles In more detail

Location Moervaartkaai: in the background cooling tower Power plant Rodenhuize

Production site UNILIN: the white cloud in front of the passing car and on the quay is spilled material

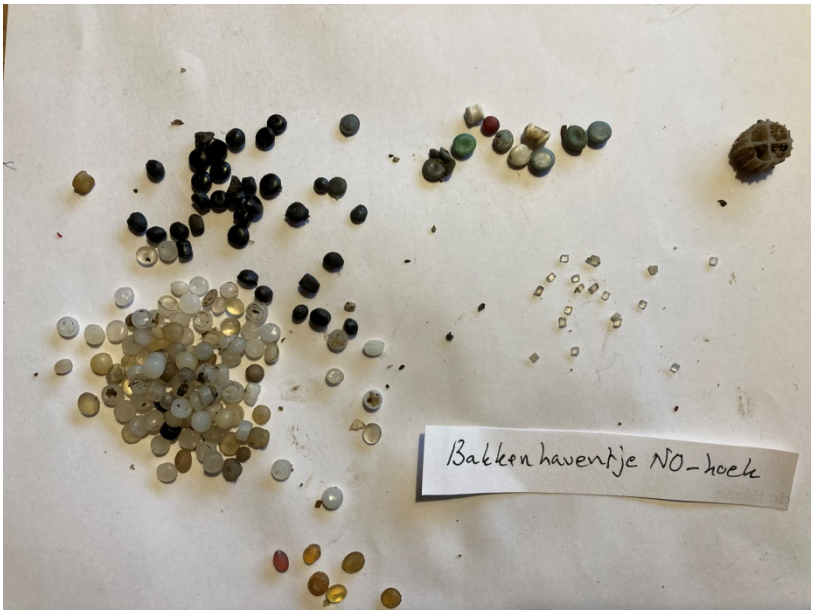


Sample of the ‘white hail’ material

location	GT2
location	Rodenhuizedok NO-hoek
date	12-11-2021
Coordinates (Google Maps)	X= 51.14558; Y=3.79915
number per m^1	100
length of deposits	20
surface total	2,000

Upper left a bio medium and an aquaculture grain. Mini-nurdles at the right. If counted they would double the score

location	GT3
location	Heide (bakkenhaventje)
date	12-11-2021
Coordinates (Google Maps)	X=51.19096 ; Y=3.80507
number per m^1	Corner/floating
length of deposits	
surface total	




A10

Sample Heide ‘Bakkenhaventje’

location	GT4
location	Autrichehaven
date	6-10-2021
Coordinates (Google Maps)	X=51.25625 ; Y=3.84091
number per m^1	500
length of deposits	20
surface total	10,000

The pencil (0,5 mm) points at transparent mini-nurdles? At the left black ones. Under the tweezer: 5 snails and 3 plant seeds. lower right are styrofoam grains

location	GT5
location	Zijkanaal C, end
date	6-10-2021
Coordinates (Google Maps)	X=51.26870 ; Y=3.87353
number per m^1	End of canal
length of deposits	-
surface total	5,000

The floating mass consists mainly of Styrofoam mixed with nurdles in relatively low numbers

location	GT6
location	Terneuzen centrum
date	6-10-2021
Coordinates (Google Maps)	X=51.33396 ; Y=3.82643
number per m^1	Floating
length of deposits	-
surface total	5,000

5 transparant mini-nurdles?

NE-corner Terneuzen Centrum Kennedylaan

Terneuzen centrum NE-corner

location	GT7
location	Terneuzen buiten sluis
date	10-8-2021
Coordinates (Google Maps)	X= 45947; Y=373512
number per m^1	10-100
length of deposits	250 m
surface total	12,500