Marine Sediment Characterisation
Magheraroarty Pier
Dredging and Disposal Operations

Produced by

AQUAFACT International Services Ltd

For

Donegal County Council

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1. Introduction

Donegal County Council is applying to the EPA for a Dumping at Sea Licence to carry out dredging at the Magheraroarty Pier and subsequent proposed beach nourishment nearby.

AQUAFACT International Services Ltd. was commissioned by Donegal County council to carry out a marine sediment characteristation survey of the dredge area at Magheraroarty Pier.

2. Materials & Methods

2.1. Sample Processing

On the 21th January 2020, 3 sediment stations were sampled for physical and chemical analysis as per a request from the Marine Institute (see Appendix 3). AQUAFACT's Lencraft rib was used to carry out the sampling. Figure 2.1 shows the station locations and Table 2.1 shows the station coordinates.

One grab sample was taken at each of the stations and the samples were divided as follows:

1. Into labelled 1l plastic bags for water content, density and sediment grain size analysis;
2. Into 120ml amber glass jars for organochlorine, PCB (polychlorinated biphenyl), PAH (polycyclic aromatic hydrocarbon), total extractable hydrocarbon, TBT (tributyl tin) and DBT (dibutyl tin) analysis;
3. Into 500ml plastic pots for metal, total organic carbon and carbonate analysis;

Figure 2.1: Location of chemistry sampling sites

Table 2.1: Coordinates of stations sampled for physical and chemical analysis.

Station	Longitude	Latitude	Depth (m)	Determinand Required
S1	-8.17377	55.14704	2.8	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
S2	-8.17317	55.14765	2.0	1, 2, 3, 4a, 4b, 4c, 4f
S3	-8.17268	55.14798	1.2	1, 2, 3, 4a, 4b, 4c, 4f

2.2. Sample Processing

Once back in the lab, all sediment samples for the analysis of organics and contaminants were sent to the SOCOTEC Laboritories in Burton on Trent. AQUAFACT carried out the particle size analysis, moisture and density content as described below.

2.2.1. Particle Size Analysis (PSA)

AQUAFACT carried out the PSA analysis in-house using the following methodology:

1. Approximately 100g of dried sediment (previously washed in distilled water and dried) was weighed out and placed in a labelled 1L glass beaker to which 100ml of a 6 percent hydrogen peroxide solution was added. This was allowed to stand overnight in a fume hood.

2. The beaker was placed on a hot plate and heated gently. Small quantities of hydrogen peroxide were added to the beaker until there was no further reaction. This peroxide treatment removed any organic material from the sediment which can interfere with grain size determination.
3. The beaker was then emptied of sediment and rinsed into a 63µm sieve. This was then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve was then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.
4. 10ml of sodium hexametaphosphate solution was added to the beaker and this solution was stirred for ten minutes and then allowed to stand overnight. This treatment helped to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution was washed and rinsed into a 63µm sieve. The retained sample was carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.
6. The dried sediment was then passed through a Wentworth series of analytical sieves (>8,000 to 63µm; single phi units). The weight of material retained in each sieve was weighed and recorded. The material which passed through the 63µm sieve was also weighed and the value added to the value measured in Point 5 (above).
7. The total silt/clay fraction was determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.
8. The following range of particle sizes: <63µm, 63<125µm, 125<250µm, 250<500µm, 500<1000µm, 1000<2000µm, 2000<4000µm and 4000<8000µm were reported.

2.2.2. Moisture Content & Density

Moisture content was taken as the percentage weight difference between the wet and dried sediment. Sediment density was calculated by placing a fixed volume (100 ml) of sediment in a volumetric cylinder and weighing the contents.

2.2.3. Chemical Analysis

The following methodologies were employed by SOCOTEC Burton-upon-Trent:

- Total Solids: Calculation (100%-Moisture Content).Moisture content determined by drying a portion of the sample at 120°C to constant weight.
- Total Hydrocarbons: Solvent extraction and clean up followed by GC-FID analysis.
- Organotins: Solvent extraction and derivatisation followed by GC-MS analysis.
- Metals: Aqua-regia extraction followed by ICP analysis.
- PAH analysis: Solvent extraction and clean up followed by GC-MS analysis.

All testes were carried out on the <2mm fraction.

The Limits of detection can be seen in Table 2.2.

Table 2.2: Limits of Detection

Parameter	Unit	LOD
Hydrocarbons	µg/kg	100
Mercury	mg/kg	0.01
Aluminium	mg/kg	10
Arsenic	mg/kg	1
Cadmium	mg/kg	0.1
Chromium	mg/kg	0.5
Copper	mg/kg	2
Lead	mg/kg	2
Lithium	mg/kg	0.5
Nickel	mg/kg	0.5
Zinc	mg/kg	3
OCP	µg/kg	0.1
PAH	µg/kg	1
PCBs	µg/kg	0.08
DBT/TBT	mg/kg	0.001

3. Physical / Chemical Results

3.1. Parameter Code 1

Table 3.1 shows the visual inspection information, which includes colour and sediment type.

Table 3.1: Visual Inspection

Station	Description
S1	Brown clean sand
S2	Brown clean sand
S3	Brown clean sand

3.2. Parameter Code 2

The water content and density results can be seen in Table 3.2. Values ranged from 1.53 (S2) to 1.55g/ml (S1 andS3) for density and from 33.79 (S1) to 37.68% (S2) for moisture content.

Table 3.2: Moisture content and density

Station	Density (g/ml)	Moisture Content (%)
S1	1.55	33.79
S2	1.53	37.68
S3	1.55	35.23

3.3. Parameter Code 3

Table 3.3 shows the granulometry results broken down into % gravel (>2mm), sand (<2mm >63μm) and mud (<63μm). Gravel ranged from 0.2 (S2) to 3.7% (S1), sand ranged from 93.1% (S1) to 98.6% (S3) and silt-clay ranged from 1.1% (S3) to 3.6% (S2).

Table 3.3: Granulometry results

Station	% Gravel (>2mm)	% Sand (<2mm - > 63□m	% Silt-Clay (<63□m)
S1	3.7	93.1	3.3
S2	0.2	96.2	3.6
S3	0.4	98.6	1.1

3.4. Parameter Code 4

3.4.1. Code 4a

Table 3.4 shows the total organic carbon results. Values ranged from 0.20 (S3) to 0.66% (S1).

Table 3.4: Total organic carbon results

Station	TOC %
S1	0.66
S2	0.27
S3	0.20

3.4.2. Code 4c

Table 3.5 shows the metal results. Mercury (Hg) levels ranged from 0.01 (S3) to 0.04mg/kg (S1). Aluminium (Al) levels ranged from 4,900 (S2) to 7,900mg/kg (S1). Arsenic (As) levels ranged from 1.6 (S3) to 3.3mg/kg (S1). Cadmium (Cd) levels were below the limits of detection at all three stations (<0.1mg/kg). Chromium (Cr) levels ranged from 7 (S3) to 10.1mg/kg (S1). Copper (Cu) levels ranged from 2.3 (S3) to 4.8mg/kg (S1). Results for Lithium (Li) levels ranged from 4.58 (S3) to 5.34mg/kg (S1). Lead (Pb) levels ranged from 3.5 (S2) to 6.1mg/kg (S1). Nickel (Ni) levels ranged from 3.3 (S3) to 5mg/kg (S1). Zinc (Zn) levels ranged from 11.1 (S2) to 38.2mg/kg (S1).

The guidance values for metals (Cronin *et al.,* 2006) can be seen in Table 3.6 below. All heavy metals

were below the lower level guidance values.

Table 3.5: Metal results.

Station	Hg mg/kg	Al mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Li mg/kg	Pb mg/kg	Ni mg/kg	Zn mg/kg
S1	0.04	7900	3.3	<0.1	10.1	4.8	5.34	6.1	5	38.2
S2	0.03	4900	1.8	<0.1	7.2	2.5	4.64	3.5	3.9	11.1
S3	0.01	7210	1.6	<0.1	7	2.3	4.58	4.2	3.3	11.2

Table 3.6: Proposed metal guidance values for sediment quality guidelines (Cronin *et al.,* 2006).

Metal	Lower level	Upper Level
As (mg/kg)	9*	70#
Cd (mg.kg)	0.7	4.2
Cr (mg/kg)	120	370
Cu (mg/kg)	40	110^
Pb (mg/kg)	60	218
Hg (mg/kg)	0.2	0.7
Ni (mg/kg)	21	60
Zn (mg/kg)	160	410

* ERL (rounded up) – No background Irish data

In some locations natural levels of arsenic will exceed this value and in such instances this guidance value will not be appropriate.

^ PEL as ERM considered high

3.4.3. Code 4d

Tables 3.7 and 3.8 show the organochlorines including ɣ-HCH (Lindane) and PCB results. All organochlorines tested for were <0.1µg/kg. All PCB's were <0.08µg/kg.

The guidance values for organochlorines and PCBs (Cronin *et al.,* 2006) can be seen in Table 3.9 below. All PCBs are below the lower guidance level. HCB and ɣ-HCH were below the lower guidance level.

Table 3.7: Organochlorine results.

Station	DDE-pp ug/kg	DDT-pp ug/kg	Dieldrin ug/kg	HCH Alpha ug/kg	HCH Gamma ug/kg	HCB ug/kg	DDD-pp ug/kg
S1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3.8: PCB Results.

Station	PCB 028 ug/kg	PCB 052 ug/kg	PCB 101 ug/kg	PCB 118 ug/kg	PCB 138 ug/kg	PCB 153 ug/kg	PCB 180 ug/kg
S1	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08

Table 3.9: Proposed organochlorine and PCB guidance values for sediment quality guidelines (Cronin *et al.,* 2006).

Parameter	Lower level	Upper Level
ɣ-HCH (Lindane) (µg/kg)	0.3	1
HCB (µg/kg)	0.3	1
PCB (individual congeners of ICES 7) (µg/kg)	1	180
PCB (Σ ICES 7) (µg/kg)	7	1260

3.4.4. Code 4e

Table 3.10 shows the total extractable hydrocarbon results. The value for station was 21.7 mg/kg. This is below the lower guidance level of 1000mg/kg (1 g/kg) (Cronin *et al.,* 2006).

Table 3.10: Total extractable hydrocarbon results.

Station	Hydrocarbons mg/kg
S1	21.7

3.4.5. Code 4f

Table 3.11 shows the dibutyl and tributyl tin results. The results forDBT were <0.001 mg/kg for station S2 and <0.005 mg/kg at S1 and S3. Values for TBT were <0.001 mg/kg for station S2 and <0.005 mg/kg at S1 and S3. The guidance values for the sum of TBT and DBT range from a lower level of 0.1 to an upper level of 0.5mg/kg (Cronin *et al.,* 2006). All are below the lower limit.

Table 3.11: Dibutyl and tributyl tin results.

Station	DBT mg/kg	TBT mg/kg
S1	<0.005	<0.005
S2	<0.001	<0.001
S3	<0.005	<0.005

3.4.6. Code 4g

Table 3.12 shows the PAH results. Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (k) fluoranthene, Dibenzo (a,h) anthracene, Fluorene and Naphthalene were all <1µg/kg. Acenaphthene was 3.27µg/kg. Benzo (b) fluoranthene was 2.59µg/kg. Benzo (ghi) perylene was 1.85µg/kg. Chrysene was 2.87µg/kg. Fluoranthene was 5.94µg/kg. Indeno 1, 2, 3 – cd pyrene was 1.93µg/kg. Phenanthrene was 2.89µg/kg. Pyrene was 4.96µg/kg.

The lower level guidance values for the sum of all 16 PAHs is 4000 µg/kg (Cronin *et al.,* 2006). Station 1 was below the lower limit.

Table 3.12: PAH results.

Sample Number	S1
PAH Acenaphthene ug/kg	3.27
PAH Acenaphthylene ug/kg	<1
PAH Anthracene ug/kg	<1
PAH Benzo a anthracene ug/kg	<1
PAH Benzo (a) pyrene ug/kg	<1
PAH Benzo (b) fluoranthene ug/kg	2.59
PAH Benzo ghi perylene ug/kg	1.85
PAH Benzo k fluoranthene ug/kg	<1
PAH Chrysene ug/kg	2.87
PAH Dibenzo a,h anthracene ug/kg	<1
PAH Fluoranthene ug/kg	5.94
PAH Fluorene ug/kg	<1
PAH Indeno 1,2,3 – cd pyrene ug/kg	1.93
PAH Naphthalene ug/kg	<1
PAH Phenanthrene ug/kg	2.89
PAH Pyrene ug/kg	4.96

4. Discussion/Conclusion

The sediments analysed were below the lower Irish action limits for metals, organochlorines, PCBs, total extractable hydrocarbons, organotins and ∑16 PAH's (see Appendix 2 for Annex 1 action level limits table).

The suitability of the spoil for disposal at sea will be determined by the Marine Institute.

5. References

Cronin, M., McGovern, E., McMahon, T. & R. Boelens. 2006. Guidelines for the assessment of dredge material for disposal in Irish waters. Marine Environmental and Health Series, No. 24, 2006.

Appendix 1
MI Sediment Analysis Requirement

Marine Institute
Foras na Mara

Rinville
Oranmore
Co Galway
Tel: 091 387200

Cathal Sweeney
Marine Section
Donegal Co. Co.

18/12/2019

Dear Cathal ,

A proposed sampling and analysis plan is detailed below to cover dredging at the Magheraroarty Pier and subsequent proposed beach nourishment nearby.

Three samples are recommended. You should give your contractor a copy of this plan. You will need to draw their attention especially to Section 3 and Section 4 to confirm that they are capable of meeting the quality assurance standards required.

If you need clarification on anything, please don't hesitate to contact me.

Best regards,

MCronin

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Margot Cronin
Marine Environment Chemist

1.0 Sample location and analyses required:

Three surface samples, as listed in Table 1 below) should be taken[1]. Sample locations are also shown on the chart in Figure 1 at the end of this document.

Table 1. Locations and details of proposed samples

Sample No.	Depth	Longitude (° W) *	Latitude (° N) *	Parameters for analysis
1	Surface	-8.17377	55.14704	1, 2, 3, 4a, 4b, 4c, 4d, 4e, 4f, 4g
2	Surface	-8.17317	55.14765	1, 2, 3, 4a, 4b, 4c, 4f
3	Surface	-8.17268	55.14798	1, 2, 3, 4a, 4b, 4c, 4f

* Positions in decimal degrees, WGS84

2.0 Parameter Code:

1. Visual inspection, to include colour, texture, odour, presence of animals etc
2. Water content, density (taking into account sample collection and handling)
3. Granulometry including % gravel (> 2mm fraction), % sand (< 2mm fraction) and % mud (< 63μm fraction).
4. The following determinants in the sand-mud (< 2mm) fraction * :
   a) total organic carbon
   b) carbonate
   c) mercury, arsenic, cadmium, copper, lead, zinc, chromium, nickel, lithium, aluminium.
   d) Organochlorines:
      HCH and γ-HCH (Lindane),
      DDT metabolites (pp'DDT, pp'DDE, pp'DDD).
      ICES 7 PCB congeners (to be reported as the 7 individual congeners - 28, 52, 101, 118, 138, 153, 180)
   e) total extractable hydrocarbons.
   f) tributyltin (TBT) and dibutyltin (DBT)
   g) Polycyclic aromatic hydrocarbons (PAH) - Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (ghi) perylene, Benzo (k) fluoranthene, Chrysene, Dibenz (a,h) anthracene, Flourene, Fluoranthene, Indeno 1,2,3 – cd pyrene, Naphthalene, Phenanthrene, Pyrene.
   h) Toxicity tests (Microtox or whole sediment bioassay) using appropriate representative aquatic species. (This requirement will depend on the results of the chemical analyses.)

[1] Further sampling and analysis, at depth if necessary, may be required in the event that problem areas of heavy contamination are identified as a result of the initial testing.

**where the gravel fraction (> 2mm) constitutes a significant part of the total sediment, this should be taken into account in the calculation of the concentrations.*

3.0 Important notes:

3.1 The required detection limits for the various determinants are given in Table 2. below.

3.2 Details of the methodologies used must be furnished with the results. This should include sampling, sub sampling and analytical methods used for each determinant.

3.3 Appropriate marine CRM are to be analysed during each batch of analyses and the results to be reported along with sample results.

3.4 Blanks & in-house references to be run with each sample batch, and reported with sample results.

Table 2. Maximum limits of detection required

Contaminant	Concentration	Units (dry wt)
Mercury	0.05	mg kg^{-1}
Arsenic	1.0	mg kg^{-1}
Cadmium	0.1	mg kg^{-1}
Copper	5.0	mg kg^{-1}
Lead	5.0	mg kg^{-1}
Zinc	10	mg kg^{-1}
Chromium	5.0	mg kg^{-1}
Nickel	5	mg kg^{-1}
Total extractable hydrocarbons	10.0	mg kg^{-1}
TBT and DBT (not organotin)	10	µg kg^{-1}
PCB – individual congener	0.1	µg kg^{-1}
OCP – individual compound	0.1	µg kg^{-1}
DDT metabolite	0.1	µg kg^{-1}
PAH – individual compound	10	µg kg^{-1}

4.0 Reporting requirements

Reports should include the following information

4.1 Results of testing should be reported in EPA spreadsheet format, which can be found here.

4.2 Spreadsheet results to include:

- Tabulated geophysical/chemical test results
- Clear expression of units
- Indication of wet weight or dry weight basis
- Location of samples in decimal degrees WGS84 (latitude/longitude).
- Date of sampling
- Treatment of samples and indication of sub sampling, compositing etc.
- Summary method details
- CRM results
- QA /QC
- Other quality assurance information (e.g. accreditation status)
- Project details.

4.3 If determinant is not detected, report less than values, and indicate LoD/ LoQ used.

4.4 Testing laboratories may be asked to provide additional details of method performance including limit of detection, precision, bias

Figure 1. Sample positions at Magheraroarty Harbour

Appendix 2
Annex 1 Action Level Limits

ANNEX 1: TABLES

Table B.1 Results of sediment chemistry analysis of the material to be dumped at sea, with reference to Irish Action Levels [Note 1]

Parameter	Units (dry wt) [Note 2]	Lower Action Limit	Upper Action Limit	S1	S2	S3
Arsenic	mg kg^{-1}	9	70	3.30	1.80	1.60
Cadmium	mg kg^{-1}	0.7	4.2	<0.1	<0.1	<0.1
Chromium	mg kg^{-1}	120	370	10.10	7.20	7.00
Copper	mg kg^{-1}	40	110	4.80	2.50	2.30
Lead	mg kg^{-1}	60	218	6.10	3.50	4.20
Mercury	mg kg^{-1}	0.2	0.7	0.040	0.030	0.010
Nickel	mg kg^{-1}	21	60	5.00	3.90	3.30
Zinc	mg kg^{-1}	160	410	38.20	11.10	11.20
Σ TBT & DBT [Note 3]	mg kg^{-1}	0.1	0.5	<0.01	<0.002	<0.01
γ-HCH (Lindane) [Note 4]	μg kg^{-1}	0.3	1	<0.1	N/A	N/A
HCB [Note 5]	μg kg^{-1}	0.3	1	<0.1	N/A	N/A
PCB (individual congeners of ICES 7) [Note 6] PCB 028	μg kg^{-1}	1	180	<0.08	N/A	N/A
PCB 052	μg kg^{-1}			<0.08	N/A	N/A
PCB 101	μg kg^{-1}			<0.08	N/A	N/A
PCB 138	μg kg^{-1}			<0.08	N/A	N/A
PCB 153	μg kg^{-1}			<0.08	N/A	N/A
PCB 180	μg kg^{-1}			<0.08	N/A	N/A
PCB 118	μg kg^{-1}			<0.08	N/A	N/A
PCB (Σ ICES 7) [Note 6]	μg kg^{-1}	7	1260	<0.56	N/A	N/A
PAH (Σ 16) [Note 7]	μg kg^{-1}	4000		<34.3	N/A	N/A
Total Extractable Hydrocarbons	g kg^{-1}	1.0		0.0217	N/A	N/A

	Exceed Lower Irish Action Limit
	Exceed Upper Irish Action Limit

Note 1: Applicants should highlight in Table B.1 any results which exceed either the upper or lower Irish action levels. Action levels are published in: *Cronin et al. 2006. Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters. Marine Environment & Health Series, No. 24. Marine Institute.*

Note 2: Total sediment <2 mm

Note 3: Sum of tributyl tin and dibutyl tin

Note 4: 1α,2α,3β,4α,5α,6β-hexachlorocyclohexane

Note 5: Hexachlorobenzene
Note 6: ICES 7 polychlorinated biphenyls: PCB 28, 52, 101, 118, 138, 153, 180.
Note 7: Polyaromatic hydrocarbons (measured as individual compounds): Naphthalene, Acenaphthylene, Acenaphthene, Fluorene,Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene, Indeno(123-cd)pyrene.