SEDIMENT ACCUMULATION INVESTIGATION, THROUGH CALCULATION OF SEDIMENT AT DIFFERENT MORPHOLOGY AROUND DOVE ELBE.

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1. INTRODUCTION

The study of the earth's water bodies and the processes that shape them is known as Hydrography. It entails the analysis of the plants and animals that exist in or around water bodies as well as the measurement and description of the physical and chemical characteristics of water and bed surface. Ancient civilizations used rivers and oceans as means of communication and transportation, which led to the development of hydrography. Navigation, flood prediction and control, water resource management, environmental protection, and climate research are just a few of the disciplines where hydrography is now essential. Geographical, geological, biological, and meteorological knowledge are all incorporated into this interdisciplinary field. For safe navigation, it is essential to have up-to-date waterway maps and charts. Understanding river and stream water flow through the use of hydrography allows us to anticipate and control floods. Water bodies are monitored for quality using hydrography, which is also used to locate and map freshwater sources like underground aquifers. Hydrography enables us to comprehend the impact of human activities on water bodies, such as the results of pollution or the building of dams. Water's role in the earth's climate system, including the global water cycle and heat storage in the oceans, is studied using hydrography. (HCU notes, 2021)

Sediment discharge, which moves through a specific area of a river through erosion, transport, and deposition by flowing water, is important information for building a comprehensive knowledge of the river basin. River sediment is transported based on the movement of a channel as the discharge of basin sediment, which was supplied to the river via the outflow of the basin by the erosion of fertile soil. The three-stage processes of erosion, transport, and deposition all include the movement of sediment, and rivers play a part in all three. By removing the fertile soil from a basin, erosion reduces the productivity of farmland, erodes river banks or other river infrastructure, and endangers the lives and property of the general public by harming bridges, tidal outflows, weirs, fishways, or navigation facilities. Floodplains that serve a variety of purposes are damaged by transport, which also results from sediment discharge from a basin into the river channel. As a result, farming, residential areas, road infrastructure, and other areas experience deposition and banks are inundated. One of the most challenging difficulties engineers must solve is the silt issues that arise in the aforementioned procedures. Because of the topographic and hydraulic properties of the channel, silt that is introduced during a flood is deposited, reducing the cross-sectional area of flow for the river and increasing the magnitude of flood and inundation. As a result, by reducing reservoir capacity, it is crucial in interrupting the reservoir's water management and flood control functions. (Kang, J. and Ye, H. (2015)

The importance of accurate depth measurements and marine safety cannot be overstated. Field experience and training are crucial for preparing us for Hydrographic surveys. Therefore, further field training is required to help us construct the code of conduct that must be adhered to during the entire surveying procedure. Additionally, it prepares us for the working environment in the field. This report highlights the preceding planning and bathymetric survey carried out as a part of the course "Supplementary Field Training." On board the DvOcean, the survey for collecting hydrographic data was conducted on July 2, 2021. The areas that may be surveyed included the Dove Elbe area, which is the section of the Elbe between HafenCity University and Allermöher Kirchenbrücke. This report provides an insight into the applications of the hydrographic survey and methodologies involved in the process. This research would help us understand the sediment accumulation patterns through sediment mass calculation per square meter (kg/m^2) of the bed surface. Data was collected using various tools and programs, cleaned up, and processed using Qimera and QGIS. Python was used to compare various target areas and visualize data. The MBES, SBES data and SVP data acquired from DvOcean with Quincy are used for the research. MBES data is used for investigation of the sea floor and understanding the ripple patterns. Low and high frequency data are used to compare and estimate the depth of the sediments. Depth data are imported in python for visualization and calculation of mean height of the sediments layer. Five different locations are finalized for the investigation after analyzing the bathymetry of the entire survey area with MBES data.

1) Area intersecting the river.
2) Area in the middle of the river.
3) Area Infort of the lock (Tatenberger Schleuse)
4) Area Inside of the lock (Tatenberger Schleuse)
5) Bank of the river.

Python is used in Jupiter Note Book to perform mass calculations of the sediments using SBES low and high frequency data for each target area.

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2. SHIP ALIGNMENT

Any hydrographic survey that involves taking measurements depends largely on survey vessel's accuracy. This is the cause that deliberate measures are taken to guarantee that all sensor positions and vessel points are maintained. like the GNSS antennas, Echosounders, IMU unit, and other on-board equipment are accurately defined.

To guarantee that the readings from the sensors will be accurate, the locations of these sensors are crucial. Consequently, where the sensors are measured in relation to the ship's center of gravity, also known as the reference point for the ship (CoG), which is referred to as the origin of the ship (x=0, y=0, z=0), is the zero point in the local coordinate system. Typically, the positive X-axis is located to the starboard in the definition of the local coordinate system for the vessel. Positive Z-axis in the upward direction, the positive Y-axis in the forward direction, and so forth. direction. The Z-axis should be orthogonal to the waterline plane and the X- and Y-axes should be parallel to it or perpendicular to it. Typically, apparent points on the vessel (such as the waterline) are used to determine these planes. (Lekkerkerk, H-J.Theijs, M.J. 2012).

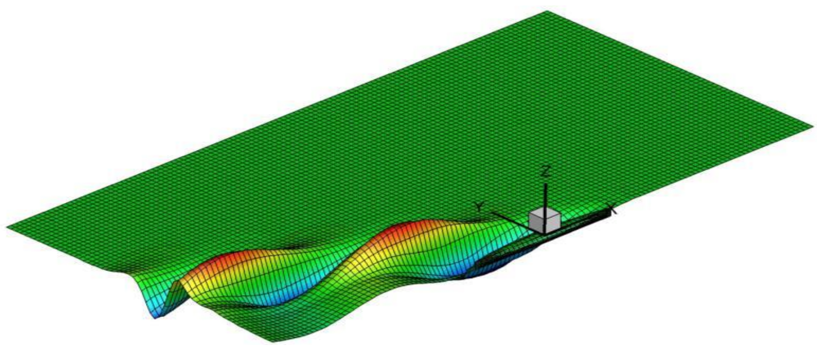

FIGURE 1 SHIP ALIGNMENT, YUAN, ZHI-MING & INCECIK, ATILLA & JIA, LAIBING (2014).

3. INSTRUMENTS

An essential component of the work done prior to the survey will be the instrumentation. According to IHO special publication S-44 Annex B.2, The equipment in use must be able to generate data that complies with the necessary standards. First thing to consider is, the total propagated uncertainties across all tools and corrections must be included in the data Secondly, there must not be any systematic errors in the equipment being used and must be determined by calibration and qualification. Other IHO publications outline the requirements for other types of equipment used in hydrographic surveying, such as echo sounders, multibeam echo sounders, and GNSS receivers. These standards are designed to ensure that hydrographic survey data collected from different sources is compatible and can be used effectively for a variety of purposes, such as nautical chart production and marine transportation. Basically, it includes the types and capabilities of the surveying and navigation equipment that the vessel should have on board. These requirements, as laid out by the IHO were met and following instruments were used for the survey. R2Sonic Multibeam Echosounder, Fahrentholz Single Beam echo sounder two RTK GNSS antennas, AML-3 LGR Sound velocity profiler, Magnetometer along with I2NS integrated inertial navigation system.

A. R2SONIC MULTIBEAM ECHO SOUNDER

The R2Sonic multibeam echo sounder is a type of tool used in hydrographic surveying to gauge the depth of the seafloor and other underwater features. It operates by sending out a series of acoustic pulses and measuring the time taken by the pulses to return to the instrument after being reflected. The R2Sonic multibeam echo sounder uses multiple sound beams to cover a large area in order to measure both the depth of the water column and the seafloor at the same time. As a result, it can quickly create maps of the seafloor that are highly detailed and precise. The R2Sonic multibeam echo sounder can measure both depth and the acoustic backscatter of the seafloor, which can reveal details about the nature and make-up of the seabed. It is frequently used in many different applications, such as the creation of nautical charts, offshore engineering, and environmental assessments. (R2Sonic 2020)

Specifications:

Sounding depth: 200 meters and more

Pulse length: 5µs -1ms

Selectable Frequencies: 200kHz – 450kHz

Max speed for full coverage: 11.1 knots

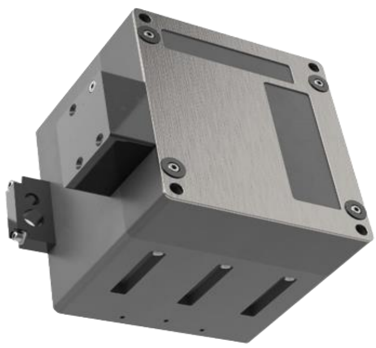

FIGURE 2 R2SONIC 2020, SUBSEAS EUROPE

B. FAHRENHOTLZ LITUBOX

Fahrenhotlz litubox SBES is a single beam echo sounder that emits a single beam of sound waves with dual frequency. Fahrenhotlz litubox operates at High frequency beams of 200kHz and low frequency of 30kHz. Working principle includes, measuring the time it taken by the waves to bounce back (the "echo") after they hit the bottom of the body of water. Using the speed of sound in water and the duration of the echo, the depth of the water can then be determined. Application areas for single beam echo sounders include hydrographic surveying, ocean engineering, and fishery research. Dual frequency can also be used to determine the sediment information at sea floor by analyzing low and high frequency SBES soundings.

C. Sound velocity profiler

SVP helps us understand the varying velocities during data acquisition. Therefore, it is important to understand the profile for more precise result. AML-3 LGR SVP is used for the DVOcean survey for the following project. It is a light weight easy to handle device with diameter of 7.6cm and weight around 1.36kg operating at up to the depth of 500m.

FIGURE 3 AML3 LGR, AML MANUAL

D. Magnetometer

SeaLINK Magnetometer was used for this project. SeaLINK also provides a real time view of the plot obtained from the magnetometer during the survey for better understanding of the data. (Marine magnetics, 2021)

Specifications includes:

1) Absolute Accuracy - 0.2 nT
2) Sensor Sensitivity - 0.02 nT
3) Counter Sensitivity - 0.001 nT
4) Resolution - 0.001 nT.
5) Range - 18,000 nT to 120,000 nT.
6) Sampling Range - 4Hz – 0.1Hz

FIGURE 4 SEALINK MAGNETOMETER, MARINE MAGNETICS 2021, SPECIFICATION

E. Integrated navigation system

Integrated navigation system provides reliable geo-referencing and motion adjustment for hydrographic surveys. The R2Sonic Wideband Multibeam Echosounder Systems (MBES) and R2Sonic I2NS work in perfect harmony to deliver precise measurements. It is possible to mount the R2Sonic I2NS IMU on the vessel's center of rotation or in its small, waterproof housing. I2NS operate and control through the Graphical User Interface (GUI)'s built-in monitoring window. Even in locations where multipath affects GPS reception, the R2Sonic I2NS provides continuous positioning data. (R2sonic I2NS, Spec sheet version 3.0)

FIGURE 5 I2NS, I2NS SPEC SHEET 3.0

4. SURVEY LOCATION AND DATA ACQUISITION

As a part of Supplementary field training, survey was supposed to be conducted with DvOcean which was a hydrographic survey vessel form HCU. Survey was conducted June 30th 2021 until 9th July 2021 with Multibeam and single beam echo sounders including magnetometer and others. Survey data form MBES, SBES and SVP for mentioned survey location is used for the research. Survey area for the project was Dove Elbe region including Tantenberger Schleusse (The lock). Group of 4 students were onboard for data acquisition to survey for individual research project. Planning of survey area includes investigating the safe and effective route for the research project. Nautical charts along with tide data were considered for the survey date. Requirements of IHO for the quantity, orientation, and speed of sounding lines were met.
Generally speaking, the sounding lines were designed so that the majority of the data would be gathered perpendicularly to distinguish between objects. (IHO, International Hydrographic Organization Standards for Hydrographic, 2020)

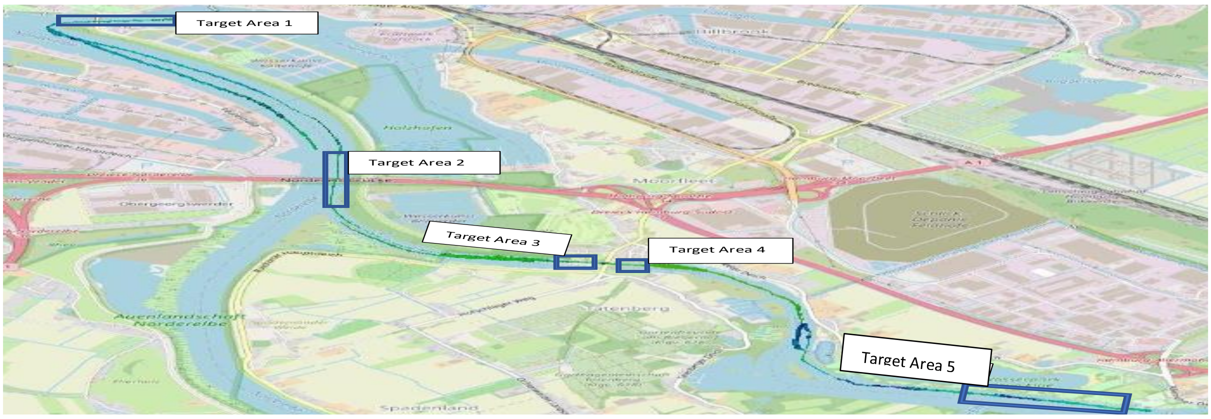

FIGURE 6 TOTAL SURVEY AREA AND TARGET ZONES, QIMERA, QGIS

TABLE 1 TARGET LOCATION AND THEIR AREA IN SQUARE METERS

Target	Location	Area as per Qimera (m^2)
1	Intersecting the river.	8050.50
2	Mid-section of the river.	5443.01

3	Infort of the lock.	1423.81
4	Inside the lock.	393.31
5	Bank of the river.	12155.63

5. RESEARCH QUESTION

Study and investigation of sediments has always been a vital topic for river projects. Sediment load that passes through different locations of river due to erosion and transportation are very important source of information for the basic flood management and other environmental preservation projects. Erosion lowers the farm yield causing the destruction of farmland by removing the rich soil of a basin. Bridges, tidal outlets and navigational aids endangers the public's lives and property. (Kang, J. and Ye, H, 2015).

Therefore, Research topic as a part of supplementary field training is an approach to understand the dynamics of "Sediment accumulation investigation based on sediment calculation at diverse location of Dove Elbe".

A. THEORY

Sediment is the material transported by a river and deposited at different locations of it. Higher the velocity of the river larger the material carried by it. Basic principle behind deposition of river sediments states that the sediment occurs due to reduced energy/velocity of the river. Due to reduced velocity suspended particles settles at the bottom of the river bed. Situations when a river experiences velocity drop are: (internet Geography)

1) Area where it meets another water body.
2) Area where a river enters is relatively shallow.
3) Inside bend of meander.
4) Area where the river flow is slower.
5) Base of waterfall.

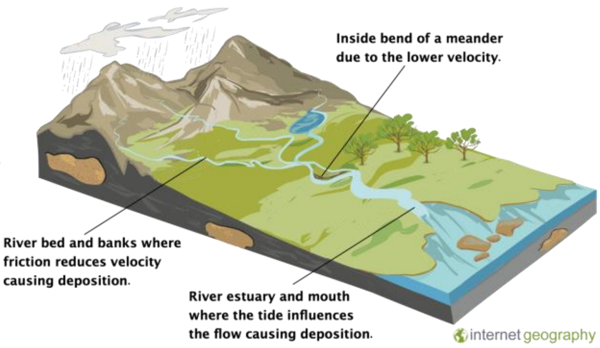

FIGURE 7 SEDIMENT DEPOSITION LOCATIONS, INTERNET GEOGRAPHY

Stream channels are constantly changing due to the movement of water and sediment. These changes can affect the size, shape, and material of the channel. The material that makes up the bed, banks, and floodplain of a stream is carried and deposited by the water and can be moved again under certain conditions. A stream channel is considered stable when the flow of water and amount of sediment are balanced over time. If there is a change in either of these factors, the channel will adjust its slope, depth, width, meander pattern, bed composition, and vegetation density. (Waters, T. F, 1995)

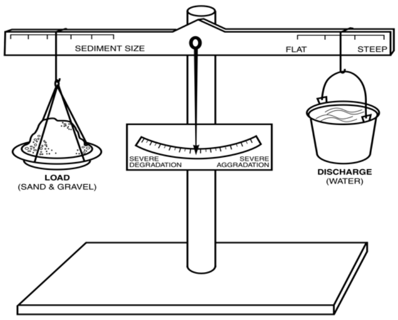

FIGURE 8 STREAM BALANCE, (WATER NOTES17, 2000)

B. ELBE

The river Elbe drains an area measuring 148,268 km2 over a distance of more than 1,000 km. Final 172 km of which experiences tide from the North Sea. The river splits and the width vary between 300-500m. This widening of the river drops the flow velocity and enhances the sediment along the banks of the river. Branch narrows to about 200m before continuing to widen through the Hamburg Port. The main channel is about 500 meters wide where the two branches converge.

Along the Elbe Estuary, in particular, a large number of sediment sample have been examined. These exhibit the fact that most of the bed material is fine and within the main channel. Medium-sized sand, with the finest particles concentrated in the shallower areas next to the channel. The D60 In contrast to the deep, (particle size) in these shallow areas is typically below 200 microns. The characteristic size (D60) of the mouth region channels is between 200 and 400 microns. In the. The sediments in the main Port areas are much finer and contain 42–58% clay particles. whose D60 values fall between 65 and 95 microns. Hamburg Port Authority (2011). Hence density for this research topic is set to be the density for wet clay 1300kg/m3. (BIPM, 2022)

	Designation/Name	Elbe km	Type of Dredged Material
BA1	Wedel	638.9 – 644.0	Silt/fine sand
BA2	Lühesand	644.0 – 649.5	Predominantly medium sand
BA3	Juelssand	649.5 – 654.4	Silt/fine sand
BA4	Stadersand	654.5 – 659.0	Predominantly medium sand
BA5	Pagensand	659.0 – 664.5	Fine/medium sand
BA6	Steindeich	664.5 – 670.0	Predominantly (medium) sand
BA7	Rhinplate	670.0 – 676.0	Predominantly medium sand, some fine-sand / silty areas
BA8	Wischhafen	676.0 – 680.5	Almost exclusively (medium) sand
BA9	Freiburg	680.5 – 685.5	Almost exclusively (medium) sand
BA10	Scheelenkuhlen	685.5 – 689.8	Almost exclusively (medium) sand
BA11	Brunsbüttel	689.8 – 698.5	Predominantly medium sand, some fine-sand / silty areas
BA12	Osteriff	698.5 – 709.9	Fine sand/silt
BA13	Medemgrund	709.0 – 717.0	Predominantly (fine) sand
BA14	Altenbruch	717.0 – 726.0	Predominantly (fine) sand
BA15	Leitdamm Cuxhaven	726.0 – 732.0	Predominantly (fine) sand
BA16	östliche Mittelrinne	732.0 – 739.0	Fine to coarse sand
BA17	westliche Mittelrinne	739.0 – 748.0	Fine to coarse sand

FIGURE 9 SEDIMENT MATERIALS IN ELBE HAMBURG REGION, REVIEW OF SEDIMENT MANAGEMENT STRATEGY IN THE CONTEXT OF OTHER EUROPEAN ESTUARIES FROM A MORPHOLOGICAL PERSPECTIVE

C. PROJECT AIM

Aim of the project is to investigate the sediments accumulation pattern through the calculation and estimation of sediment mass with MBES and low & high frequency SBES data. Select 5 different target locations through visualization of sediments and ripple patterns of the bathymetry. Process and clean MBES data in Qimera followed by visualizing in FMGT software to figure out best possible target locations. Import SBES low and high frequency data for depth comparison and sediment mass calculation with python.

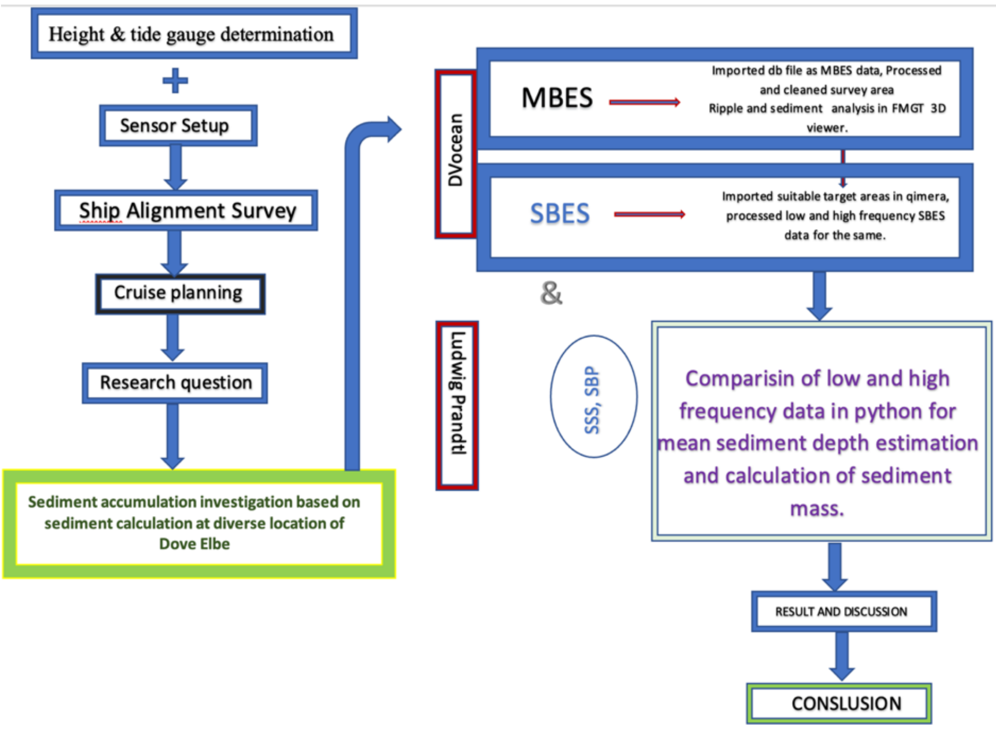

FIGURE 10 PROJECT WORK FLOW

6. DATA ANALYSIS

A. MULTIBEAM ECHO SOUNDER

The Multi-Beam Echo-Sounder used for the survey was R2Sonic 2020. The model is small, light, highly portable, and easily operated by inexperienced surveyors. The R2 Sonic 2020 offers a frequency range of 200-400 kHz, which places the frequency used on this survey in approximately the mid-range at 350 kHz. The system is meant for depths of up to 200 meters and is equipped with roll, pitch stabilized beams as well as Near-field focusing (R2Sonic, 2021).

Acquisition software Quincy was used for data acquisition and "Qimera" was used to process the beam data that were acquired. The multibeam data was initially uploaded and followed by automatic processing and automatic selection of survey data coordinate system to ETRS89/UTM zone 32N + GCG2016. Corresponding dynamic surfaces were created using the raw sonar files. Dynamic surface was then cleaned using swath editor and exported as .tiff format for visualization and geo referencing in QGIS. Cleaned bathymetry was then visualized in FMGT software to select the best survey locations that helps understand the overall features of river sediment dynamics. Conditions mentioned for possible velocity drop in section (5.A) were considered while selecting the diverse target locations within the survey area.

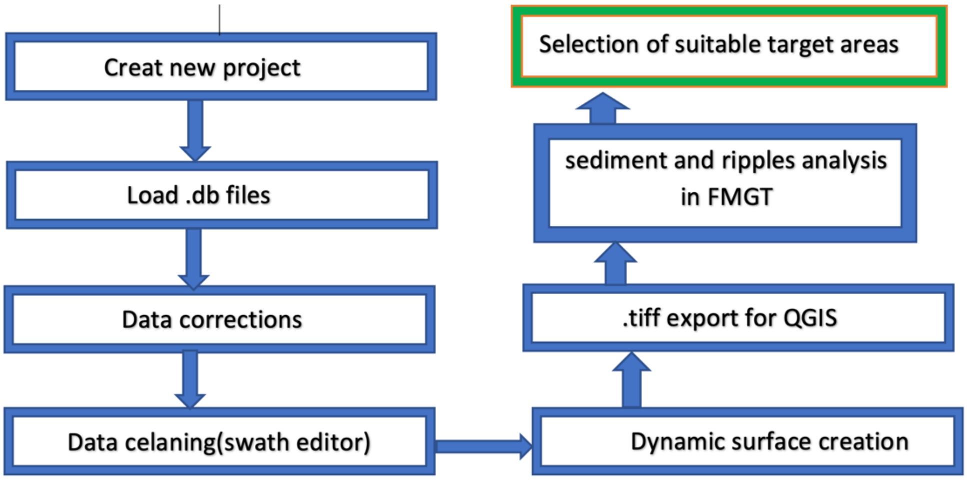

FIGURE 11 WORKFLOW, VISUALISATION OF BATHYMETRY FOR SUITABLE TARGET AREA

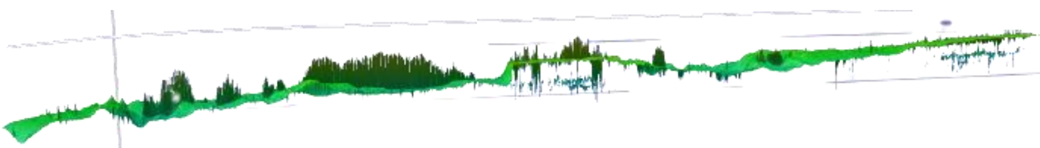

FIGURE 12 TARGET 1 BEFORE CLEANING, AREA AT INTERSECTION

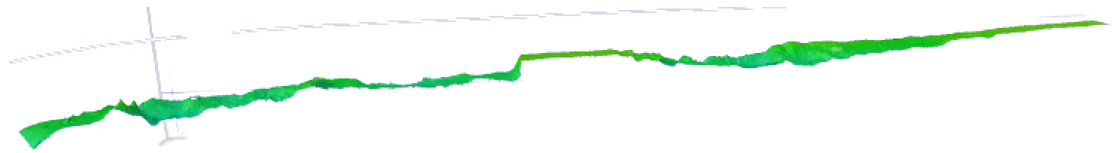

FIGURE 13 TARGET 1 AFTER CLEANING, AREA AT INTERSECTION

After cleaning raw data, dynamic surface for low and high frequency are created to investigate the possible areas of interest. software tool Fledermaus version 8.4.4 was used to visualize the fluctuations in depth layers of the entire survey area. We consider that high frequency soundings represent the top layer of the sediment deposits while low frequency sounding represents the lower layer of the sediments.

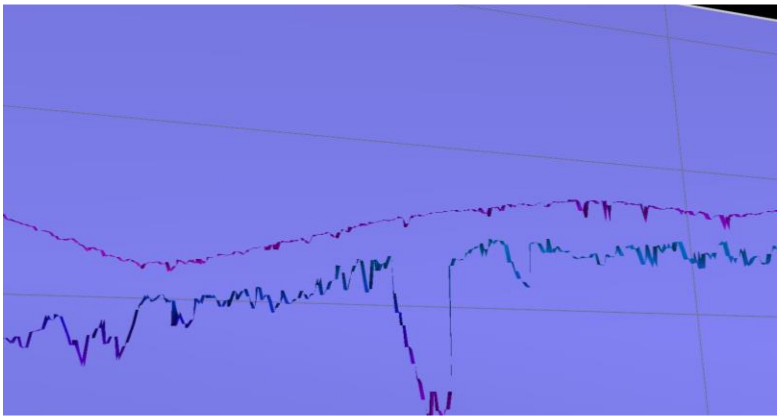

FIGURE 14 LOW AND HIGH FREQ SOUNDINGS REPRESENTING THICK SEDIMENT LAYER, FLEDERMAUS 8.4.4

Following locations were finalized for the research project.

FIGURE 15 SURVEY LOCATION 1, NEAR INTERSECTING AREA OF THE RIVER.

FIGURE 16 SURVEY LOCATION 2, AT MID-SECTION OF THE RIVER.

FIGURE 17 SURVEY LOCATION 3, INFRONT OF THE LOCK.

FIGURE 18 SURVEY LOCATION 4, INSIDE THE LOCK.

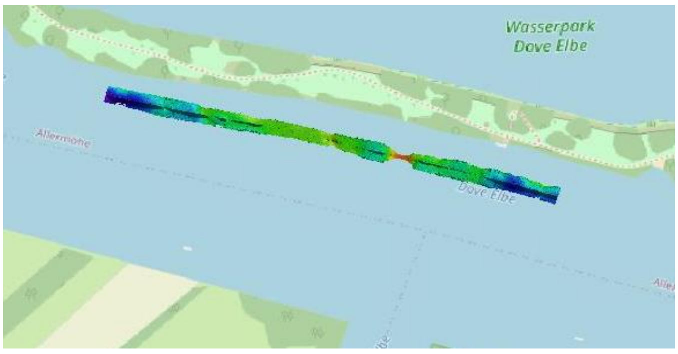

FIGURE 19 SURVEY LOCATION 5, AT RIVER BANK.

B. SINGLE BEAM ECHO SOUNDER

Much like MBES, Single Beam Echo-sounders can map the sea floor by measuring the amount of time needed for an acoustic ping to reach the seafloor and return. SBES however only transmits a single acoustic pulse, the travel time of which is then used to calculate depths and sedimentation (Flanders Marine Institute, n.d.).

SBES is capable of producing very accurate position and height measurements for points along the seafloor in real-time. SBES records profiles of the ocean floor which are then displayed "in the presumed gradient direction of the seafloor". Profiles are generally parallel to one another and the distance between each one is indicative of irregularities in the topography of the survey area (Bundesamt für Seeschifffahrt und Hydrographie, n.d.).

Low-frequency transmissions have a high penetration rate and a low resolution. High frequencies of about 200 kHz are commonly used for shallow-water surveys. while low frequencies between 24-33 kHz are used for deep surveys. However, low-frequency transmissions are also useful if there are suspended sediments in the water column since the transmission is capable of reaching the bottom despite interference (CEE Hydrosystems, n.d.). SBES low and high frequency for the survey are used for this research topic and comparison between depth data(Z-Footprint) for these data provided helped us understand the sediment mass in the area. Qimera is used for cleaning and processing of data while python interface is used for comparison and visualization of the sediment depth data. Workflow for the investigation can be summarizes as provided bellow.

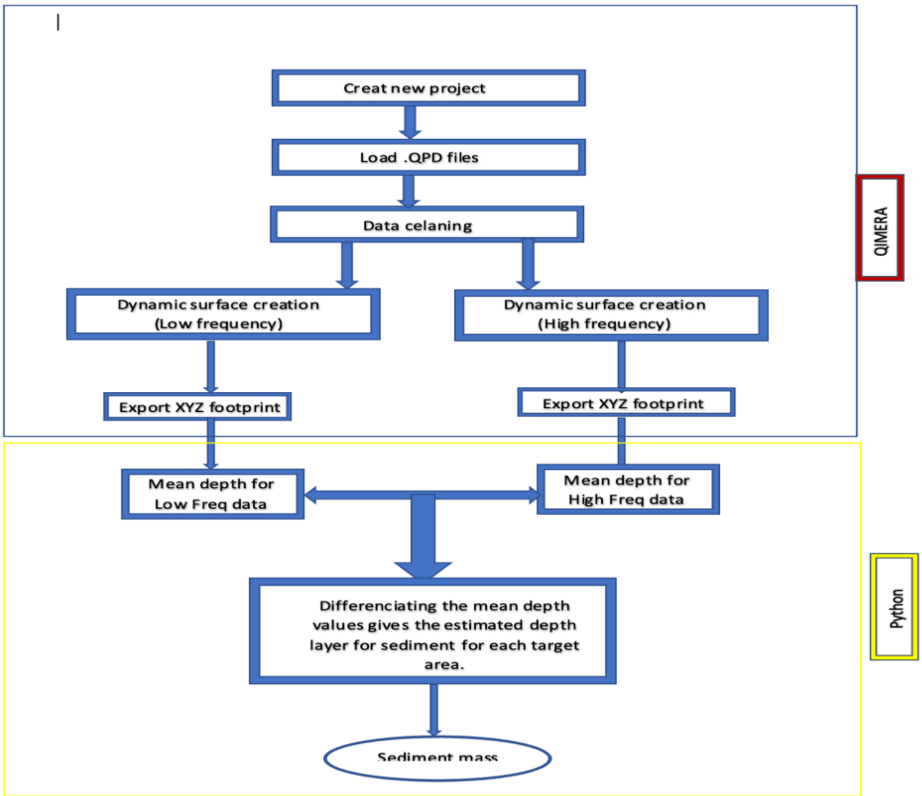

FIGURE 20 WORK FLOW, SBES DATA ANALYSIS FOR SEDIMENT MASS DETERMINATION

After Selecting the appropriate area of investigation. Intended survey lines are imported in Qimera and processed for both low and high frequency soundings. Soundings are then exported separately for further sediment mass calculation. Sediment mass determination for the intended target areas is performed in python. Python is known for its simplicity, readability, and flexibility, which make it a popular choice for beginners and experienced programmers alike. Wide range of libraries and frameworks that support a variety of programming tasks, including data analysis, machine learning, and scientific computing. After cleaning noise form data in Qimera, footprint (x, y, z) data along with horizontal and vertical uncertainty data are exported for further calculations. It is important to check and correct the uncertainties in data hence we need horizontal and vertical uncertainties from the source data.

	#Date Time	Footprint X	Footprint Y	Footprint Z
0	2021-07-02 14:06:35.697	568995.323	5931523.039	7.401
1	2021-07-02 14:06:35.785	568995.393	5931523.251	7.399
2	2021-07-02 14:06:35.874	568995.476	5931523.463	7.397
3	2021-07-02 14:06:35.963	568995.541	5931523.712	7.905
4	2021-07-02 14:06:36.051	568995.625	5931523.920	7.903
...	...	...	...	...
1949	2021-07-02 14:09:29.211	569535.836	5931626.613	4.948
1950	2021-07-02 14:09:29.300	569536.122	5931626.647	4.940
1951	2021-07-02 14:09:29.388	569536.405	5931626.689	4.974
1952	2021-07-02 14:09:29.477	569536.692	5931626.753	4.962
1953	2021-07-02 14:09:29.565	569536.975	5931626.798	4.954

FIGURE 21 XYZ FOOTPRINT CSV DATA FOR TARGET 1, JUPITER NOTEBOOK

7. RESULT AND DISCUSSION

After processing and comparing all five target areas with python following results can be drawn from the outputs and data obtained from Jupiter note book.

A. TARGET 1

Target area 1 covering the area of 8050.50 m^2 (Qimera) near the point where Alte Dove-Elbe meets Norderelbe as mentioned in section 5.1.A. Mean depth of the sediment after depth comparison from low and high frequency data in python was calculated to be 0.11097031729785035m(Jupiter note book). Estimating the wet density of the sediment to be 1300kg/m^3. Calculated sediment mass per unit area for the target area is 144.26141248720546kgs. (Jupiter note book) We can notice that the mean depth form high and low frequency data is stable within the range of around 5.94 to 6.05. this shows stable flow and ebb current has not much influence on this portion of the river.

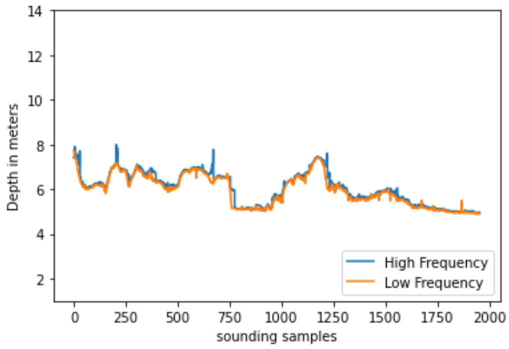

FIGURE 22 GRAPHICAL REPRESENTATION OF LOW AND HIGH FREQUENCY DEPTH DATA FOR TARGET AREA 1

B. TARGET 2

Target area 2 covering the area of 5443.01 m^2 (Qimera) at the mid-section of the river (Norderelbe) flow velocity is supposed to be maximum. Mean depth of the sediment after depth comparison from low and high frequency data in python was calculated to be 0.23280834803056988m (Jupiter note book) estimating the wet density of the sediment to be 1300kg/ m^3. Calculated sediment mass per unit area for the target area is 302.65085243974085kgs (Jupiter note book). We can notice that the mean depth form high and low frequency data is stable within the range of around 6.5 to 6.7. Ripples can also be seen in the sediment pattern.

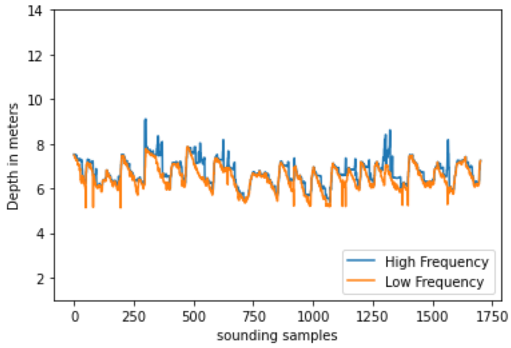

FIGURE 23 GRAPHICAL REPRESENTATION OF LOW AND HIGH FREQUENCY DEPTH DATA FOR TARGET AREA 2

C. TARGET 3

Target area 3 covering the area of 1423.81 m2 (Qimera) at the water fall before the lock(Tatenberger Schleuse). Flow velocity is depending on the closing and opening of the lock and water level of the river area inside the lock. Mean depth of the sediment after depth comparison from low and high frequency data in python was calculated to be 0.15812533814247046m (Jupiter note book) estimating the wet density of the sediment to be 1300kg/m3. Calculated sediment mass per unit area for the target area is 205.5629395852116kgs (Jupiter note book). We can notice that the mean depth form high and low frequency data is stable within the range of around 3.5m to 3.7m.

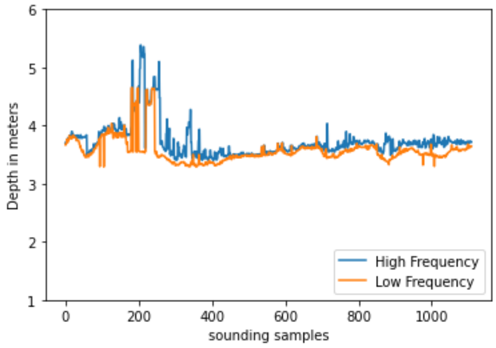

FIGURE 24 GRAPHICAL REPRESENTATION OF LOW AND HIGH FREQUENCY DEPTH DATA FOR TARGET AREA 3

D. TARGET 4

Target area 4 covering the area of 393.31 m^2 (Qimera) inside the river where flow velocity depends upon the closing and opening of the locks. Mean depth of the sediment after depth comparison from low and high frequency data in python was reported to be 0.1426304627249356m (Jupiter note book) estimating the wet density of the sediment to be 1300kg/m3. Calculated sediment mass per unit area for the target area is 185.41960154241627kgs (Jupiter note book). We can notice that the mean depth form high and low frequency data is stable within the range of around 3.5 to 3.7.

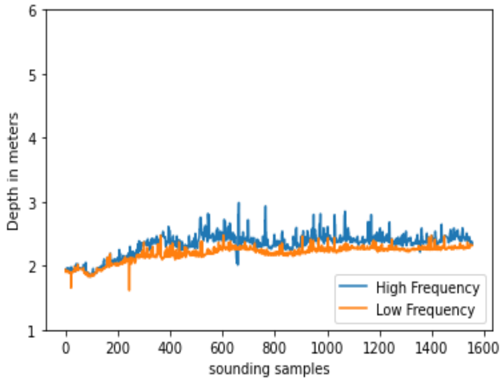

FIGURE 25 GRAPHICAL REPRESENTATION OF LOW AND HIGH FREQUENCY DEPTH DATA FOR TARGET AREA 4

E. TARGET 5

Target area 5 covering the area of 12155.63 m^2 (Qimera) near the river bank where flow velocity decreases due to shallow surface area. Mean depth of the sediment after depth comparison from low and high frequency data in python was calculated to be 0.8340356943669817m (Jupiter note book) estimating the wet density of the sediment to be 1300kg/m3. Calculated sediment mass per unit area for the target area is 1084.2464026770763kgs (Jupiter note book). We can notice that the mean depth form high and low frequency data is highly unstable within the range of around 6.3 to 7.2.

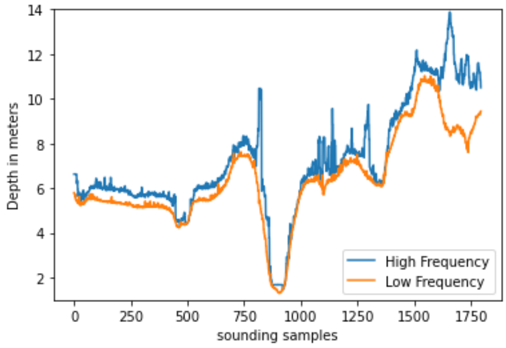

FIGURE 26 GRAPHICAL REPRESENTATION OF LOW AND HIGH FREQUENCY DEPTH DATA FOR TARGET AREA 5

Target	Area sqm	Sediment thickness (m)	Sediment mass per unit area (kg)	Volume of sediment per unit area Kilo liters
area1	8050.5	0.110970317	144.2614125	5.943504094165815
area2	5443.01	0.232808348	302.6508524	6.503245149911806
area3	1423.81	0.158125338	205.5629396	3.5736798917944084
area4	393.31	0.142630463	185.4196015	2.1972731362467854
area5	12155.63	0.834035694	1084.246403	6.378535415504735

TABLE 2 SEDIMENT THICKNESS, MASS PER UNIT AREA AND COLUME OF THE WATER OF THE OBSERVED AREAS, JUPITER NOTE BOOK

Linear regression can be plotted for the surveyed area in dove Elbe i.e., area3 area4 and area5 to check the effect of volume of water over sediment mass in dove Elbe area. Sediment mass is taken to be dependent and volume per unit area is considered to be independent variable for the same. It can be seen that the R-Squared (R^2 or the coefficient of determination) in the regression model fit well in regression model with a very high value of 0.9074. on the other hand when we combine the sediment and volume data for dove Elbe and Norderelbe R-Squared value drops to 0.212.

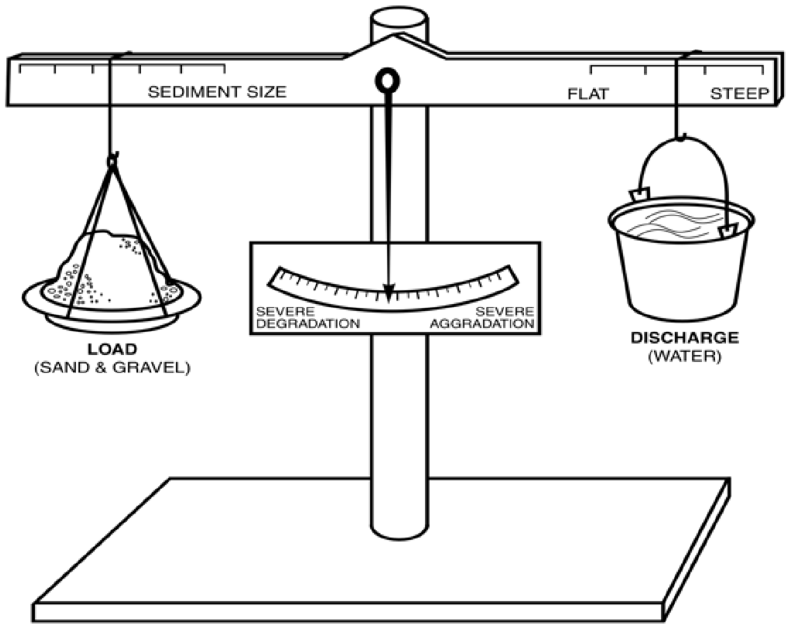

FIGURE 27 SEDIMENT LOAD AND WATER DISCHARGE, (WATER NOTES17

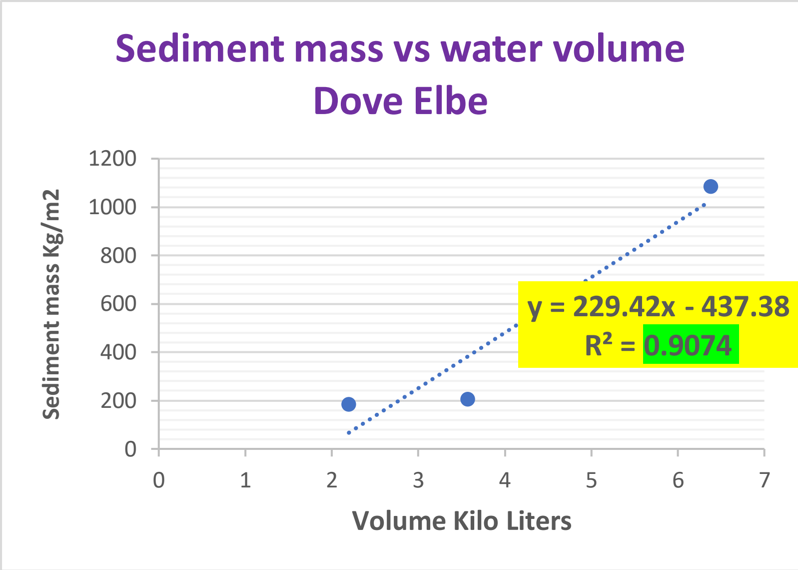

FIGURE 28 HIGHLY CORELATED, LINEAR REGRESSION GRAPH SHOWING RELATION BETWEEN SEDIMENT MASS OVER WATER VOLUME, FOR DOVE ELBE.

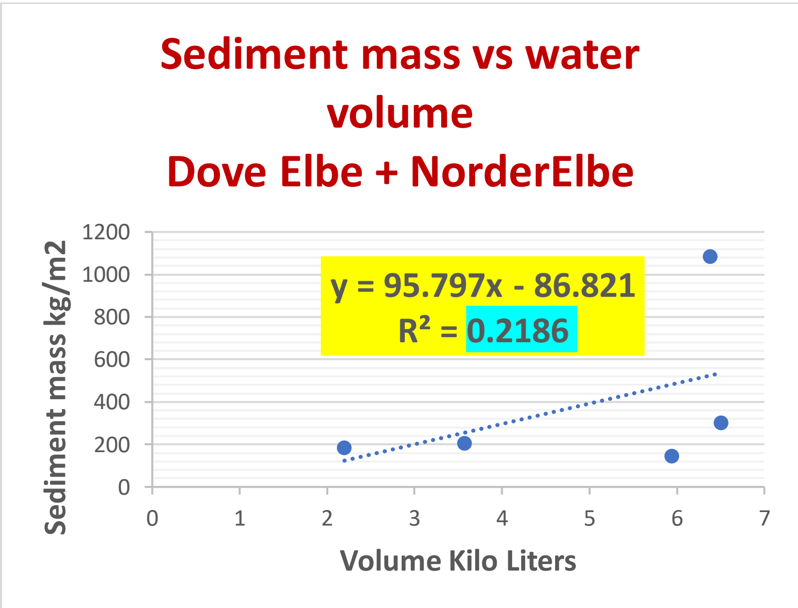

FIGURE 29 NONE CORELATED, LINEAR REGRESSION GRAPH SHOWING RELATION BETWEEN SEDIMENT MASS OVER WATER VOLUME, FOR DOVE ELBE AND NORDERELBE COMBINED.

8. CONCLUSION

The overall sediment pattern of the areas surrounding Dove Elbe is revealed by the findings and analysis of the area of interest. Target 1 had the least amount of silt buildup, due to the adjacent water mass with much stronger Flow movement. Despite the very high and steady flow velocity, Target2, located at the middle of the Norderelbe, accumulated a substantial amount of sediment. This is due to the morphology of the river belt. Despite the lock, there is no shifting sediment mass along either side of the lock in the area of interest 3 and 4. This is a result of the area around the lock having well-structured and paved surfaces. Regular water flow through the lock area also helps to maintain low sediment accumulation. Highest amount of sediment was accumulated at Target 5, which is close to the riverbank. This is as a result of the river's structure near the banks changing morphologically, which caused the flow velocity to decrease. This analysis can be used to understand the sediment pattern of the Dove Elbe region and other morphologically similar rivers and canals.

It can also be concluded that the relation between volume of water and sediment deposit for a river with similar morphology is linear as mentioned in figure 27 and may not be corelated for 2 different rivers with unique geomorphology as mentioned in figure 28.

Therefore, the project's overall goal of understanding the sediment pattern around various morphologies in and around dove Elbe region was successful. In addition to the research topic, the overall Field Training provided a summary of the use of hydrographic techniques, applications, and hands-on experience with Single Beam and Multibeam echo sounders and other instruments used in hydrographic surveys. This overview will not only help me comprehend the subject matter better, but will also encourage me to think broadly in the field of science and technology.

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