OpenHyPE - Förderprojekt

NRW Groundwater Data - OpenHygrisC Data Processing for Education (OpenHyPE)

- Gefördert durch das Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz NRW (MULNV)
- Laufzeit: 15.12.2021 31.12.2022

Table of Contents

- 1. Introduction
- 1.1 Problem statement
- 1.2 Goal
- 2. Implementation
- 2.1 Data flow
- 2.2 PostgreSQL/PostGIS
- 2.3 Data Engineering
- 2.3.1 Downloading the data
- 2.3.2 Python
- 2.3.3 Anaconda
- 2.4 PostgreSQL/PostGIS
- 2.5 QGIS
- 3. Dashboard
- 4. Result
- 5. Project Codes

1. Zusammenfassung

Das Landesamt für Natur-, Umwelt- und Verbraucherschutz (LANUV) stellt umfangreiche Grundwassermessdaten bezüglich Menge und Qualität als offene Daten bereit. Die landeseigenen Internet-Datenplattformen ELWAS und HygrisC sind zwar optimiert, die Daten zu finden und herunterzuladen, aber sie sind nicht leicht zu bedienen und bieten selbst nur sehr einge-schränkte Analysemöglichkeiten der raum- und zeitbezogenen Daten. Deshalb sollen im Projekt OpenHyPE ein erster Grundstock praxisorientierter Lehrmaterialien entwickelt werden, die beschreiben, wie man selbst eine Geodatenbank – OpenHyPE DB genannt – aufbauen kann, die dann mit den unter dem Namen OpenHgrisC bereitgestellten offenen Grundwasserdaten gefüllt wird.

Die OpenHyPE DB basiert auf ProstgreSQL/PostGIS und bildet das Zentrum eines Systems zur Analyse und Darstellung von Umweltdaten. Es wird beschrieben, wie das geographische Informationssystem QGIS sowie die Programmiersprache Python genutzt werden können, um die Daten zu selektieren, zu analysieren und in Form von Karten oder Zeitreihen darzustellen. Alle verwendeten Software-Produkte sind "Free and Open Source Software" (FOSS). Das offene Lehrmaterial wird als "Open Educational Resource" (OER) veröffentlicht und richtet sich aufgrund des abgestuften Schwierigkeits-grads sowohl an Studierende als auch Schülerinnen und Schüler des Landes Nordrhein-Westfalen und darüber hinaus. Die initiale Anschubfinanzierung des OpenHyPE-Projekts soll dazu genutzt werden, den wertvollen Umweltdatenbestand des Landes bei jungen Menschen bekannter zu machen und durch die Verbindung von Umweltwissenschaften mit Informatik einen Beitrag zur interdisziplinären MINT-Förderung allgemein sowie zur Bildung für nachhaltige Entwicklung (BNE) im Besonderen zu leisten.

1.1 Einführung / Problembeschreibung

Das Land Nordrhein-Westfalen (NRW) betreibt über das LANUV umfassende und professionelle Messnetze zur Erfassung von Umweltdaten. Im Rahmen von Open.NRW und angetrieben durch die INSPIRE-Direktive der Europäischen Union sowie weitere Direktiven wie zum Beispiel die EU-Wasserrahmenrichtlinie (WRRL) werden vom Land NRW umfangreiche Daten-Produkte offen zugänglich und frei nutzbar auf verschiedenen Plattformen zur Verfügung gestellt (Free and Open Data).

Das Land NRW ist in Deutschland ein Vorreiter bei der Bereitstellung von offenen und (kosten)freien Geodaten. Diese Daten sind ein wahrer Schatz und bilden die Grundlage für potentiell massiven Erkenntnisgewinn im Bereich Umwelt- und Naturschutz. Trotzdem scheint es so zu sein, dass nur ein vergleichsweise kleiner Personenkreis dieses Potential wirklich nutzt. Deshalb hat sich das Projekt OpenHyPE zur Aufgabe gemacht, diesen Datenbestand in die Hochschullehre einzubauen und entsprechendes frei zugängliches Lehrmaterial zu entwickeln, dass nicht nur von Studierenden sondern auch zum Teil von Schülerinnen und Schülern genutzt werden kann, um die Grundzüge der Umweltdatenverarbeitung zu lernen. Die Anschubfinanzierung soll genutzt werden, um erste Schritte der Entwicklung solchen Training-Materials umzusetzen.

Wir verfolgen dabei das Paradigma des "Problem based learning": Die notwendigen Kenntnisse und Fähigkeiten werden anhand einer konkreten gesellschaftlich relevanten Problemstellung identifiziert und vermittelt. Die Lösung der als bedeutsam erkannten Fragestellung ist die Motivation für das Lernen.

Am Anfang wollen wir das Material anhand des Problemfelds "Grundwasserschutz" entwickeln. Das Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz NRW (MULNV) betreibt über den "Landesbetrieb Information und Technik Nordrhein-Westfalen" (IT.NRW) ein eigenes wasserbezogenes Datenportal namens ELWAS-WEB. Darin werden auch Daten der landesweiten Grundwasserdatenbank HygrisC vorgehalten. ELWAS und HygrisC bieten Außenstehenden nur eingeschränkte Möglichkeiten der explorativen Datenanalyse. Aus Sicht des Usability Engineering, das sich mit der Anwenderfreundlichkeit technischer Systeme befasst, sind hinsichtlich der Benutzbarkeit sowie der Datenanalyse-Möglichkeiten Verbesserungen wünschenswert, denn gerade die explorative Datenanalyse und das Data Mining helfen, Strukturen und Zusammenhänge zwischen den Daten zu erkennen. ELWAS und HygrisC sind deshalb nur bedingt geeignet, Grundlagen der Umweltdatenanalyse zu vermitteln, können aber im Unterricht als Begleitmaterial einfließen.

Auf dem Portal OpenGeodata.NRW werden umfangreiche Daten mit Raumbezug – auch Geodaten genannt – zur Verfügung gestellt, die oft einen Zeitbezug haben, wie z.B. Landnutzungsänderungen oder Messdatenreihen zur Wasserqualität. Dort liegen auch Auszüge der HygrisC-Grundwasser-Datenbank des Landes NRW, die unter dem Namen OpenHygrisC veröffentlicht werden. Diese Grundwasserdaten können in idealer Weise als Grundlage zum Aufbau einer eigenen Umweltdatenbank dienen, anhand derer die Lernenden Konzepte des Datenmanagements und der Datenanalyse kennenlernen.

1.2 Projektziele

Folgende Komponenten sollen realisiert werden:

- Entwicklung der OpenHyPE Geodatenbank auf Basis von PostgreSQL/PostGIS zur Verwaltung raum- und zeitbezogener Daten zu Grundwasserqualität und -menge
- Problembezogenes freies Online-Kursmaterial (OER), Tutorials, Video-Tutorials, Anleitungen, Programm-Code, unter Verwendung von Free and Open Source Software (FOSS):
 - Vorstellung des Landesamts für Natur, Umwelt- und Verbraucherschutz (LANUV)
 - Einführung in den Grundwasserschutz
 - Einführung in das Geographische Informationssystem QGIS
 - Einführung in die relationale Datenbank PostgreSQL und die Abfragesprache SQL
 - Einführung in die Geodatenbank-Erweiterung PostGIS
 - Einführung in die Verarbeitung von Geodaten mit der Programmiersprache Python
 - Installation des OpenHyPE Datenbank-Managementsystems
 - Diskussion des Datenmodells und Hochladen der OpenHygrisC-Daten des LANUV
 - Automatisches Erstellen von Diagrammen zu Zeitreihen der Wasserqualität
 - Automatisches Erstellen von Karten zur Grundwasserchemie
 - Erstellen einfacher Dashboards mit interaktiven Online-Grafiken und -Karten
 - Einführung in Data Mining (Deskriptive Statistik, Suchen nach Zusammenhängen)

2.Implementation

2.1 Data flow



2.2 PostgreSQL/PostGIS

PostgreSQL is also known as Postgres is a free and open-source relation database management system and according to the PGadmin website, "Postgres Database is the most advanced open-source database in the world". We can store the time series data as well as geometry data in Postgres. In this project, we have used PGadmin which is the most popular and powerful open-source administration platform for Postgres Database.

PostGIS: PostGIS is technically an extension of the PostgreSQL database which helps to add support for geographical objects. PostGIS is open-source and free to use.

The below image shows the PGadmin.

PDAdmin File* Object* Tools* Help*			
Browser S III % Q	Dashboard Properties 908.	Italicitos Dependencies Dependenta	
- El Servert (5)			
+ EFKahoaN	Type	Name	Restriction
+ EF Kali-park project MALTER			
+ DT Kal-park project READER	rea Faula	"RETURN ON sinumbut_geoen	romal
 iii[®]PostgoetCL 13 			
- U sivia			
- 🖶 Outabases 140			
- The environ			
> @ Cents			
>			
 Event Triopers 			
> Schwatora			
Foreign Data Wommerk			
+ TELENOLAGES			
 W Schernaz (7) 			
1 Grav			
 de trepter 			
+			
> 4L Commons			
a de Corrains			
 ID FTG Configurations 			
 Butts Database 			
 Au FTS Parasets 			
 ETS Terrelates 			
 IC Presson Tables 			
a BS FLoctone			
 Statistical with Viewa 			
+ CProcedures			
> 1.1Setuetoei			
- Ph Faties (%)			
+ Ifficial stations			
+ Imateiro ov			
+ Hitadams, stoff			
 ITI measurements 			
> messele			
+ Immercianit			
> 10 Troper Functions			
> 10 Tupes			
- III Views (7)			
 Improvement and the second seco			
+ Chinat			
- illustation			
		image 6- PGadmin	
		inage of roduitini	

Watching the below videos to understand how we can create schemas and tables in the PostgreSQL database.



Create a database and schema based on the above video.

2.3 Data Engineering

2.3.1 Downloading the data

In the first step, The data must be downloaded from here. The first zip file should be downloaded and extracted which consists of four CSV files and one instruction. image 2 shows which zip file should be downloaded.

and a second second	lar 📘 UNI 📘 Hann 📘 Cyber - & English for Ewsylso. 🔮 Antinguament - E., 😤 EADG Sourchages., 🚺 Uni	ntilek für Bude 💼 BANG seine 💽 Bekmanische /	Area	+ Other box
		information or Resolution Web	nd Tacheia attalies	
	OpenGeodata.NRW 1 😂 types	41	JSON 49 XML	
	Grundwassermessstellen NRW			
	Linensinformation: Disse Dates states unter ter Dates Bates Bates Deutschland - Zino - Version 2.11, Jac Detersatzbaschnetburg: []: Operingshit:_mail.zp Metadates in: []: Depond XMW	e Nutrung itt ohne Einschritekungen oder Bedingun	gen Auflang	
	Datien der Grundwassermessstellen in NRW als CSV			
	Daten der Grundwassermessstellen in NRW als CSV Datei	Letzte Änderung	Dateigröße	
ſ	Daten der Grundwassermessstellen in NRW als CSV Datei Die OpentrigsteC, germessatilen messwerk, EPSG2502, CDV dp	Letzte Änderung 25 10 2024 De-48 od	Dataigrolia 41.7 MB	
[Daten der Grundwassermessstellen in NRW als CSV Detei © OpentygteC.ge-messellen-meseverle, EPS628022, CBV.stp © OpentygteC.ge-wasserbard, EPS628002, CBV.stp	Letzte Änderung 28:10.2024 08:48:00 29:10.2024 08:49:08	Dateigroße 41.7 MB 100.4 MB	
[Daten der Grundwassermessstellen in NRW als CSV Detei DerthgsteC.gw-messetellen-messweie_EPS622802_CSV.zp (d) OpenhygteC.gw-vessentand_EPS62802_CSV.zp Daten der Grundwassermessstellen in NRW als Sqille Datenbank	Letzte Anderung 28-10.2021 De-48-00 29-10.2021 De-49-08	Dataigrófia 41.7 MB 100.4 MB	
[Daten der Grundwassermessstellen in NRW als CSV Detei DerritigsteCgw-messetalen-messweisgtPSG28002_CSV.zp (d) OpentigsteCgw-vessentand, tPSG28002_CSV.zp Daten der Grundwassermessstellen in NRW als Sqille Datenbank. Detei	Letzte Anderung 29-10-2021 De-48-00 29-10-2021 De-49-06 Letzte Anderung	Dataigrolla 41.7 MB 30.4 MB Datatgrolla	
[Daten der Grundwassermessstellen in NRW als CSV Detei Contright=Cgw-messetellen-messweie_EPS622602_CDV.zp Cit OpenitygteCgw-messetellen in NRW als Sqlite Datenbank Detei OpenitygteCgw-messetellen-messweie_EP9022683_Sqlite.ap	Letzte Anderung 29-10-2021 De-48-00 29-10-2021 De-49-06 Letzte Anderung 29-10-2021 De-49-05	Dataigrolla 41.7 MB 100.4 MB Dataigrolla 88.9 MB	
[Daten der Grundwassermessstellen in NRW als CSV Detei Contright/C.gw/messerten/_EPS62802_CDV.zp Cit Opentright/C.gw/messerten/_EPS62802_CDV.zp Daten der Grundwassermessstellen in NRW als Sqlite Datenbank. Detei Opentright/C.gw/messetten-messwene_EP9025632_Sglite.zp Daten der Grundwassermessetten.prs628802_Sglite.zp	Letzte Anderung 29-10-2021 Die-48-00 29-10-2021 Die-49-06 Letzte Anderung 29-10-2021 Die-49-06 29-10-2021 Die-49-25 29-10-2021 Die-49-21	Dataigrolla 41.7 MB 100.4 MB Dataigrolla 88.9 MB 200.1 MB	
I	Daten der Grundwassermessstellen in NRW als CSV Datel Deteil OpentrigsteC.gw-nesserbard_EPS628022_CEV.zp Daten der Grundwassermessstellen in NRW als Sqlite Datenbank Datel OpentrigsteC.gw-nesserbard_EPS62802_Sqlite.zp OpentrigsteC.gw-nesserbard.ePS62802_Sqlite.zp Grundwasserabsbangige Landökosysteme in NRW als Shape	Letzte Anderung 28-10-2521 08-48-00 29-10-2521 08-49-06 Letzte Anderung 28-10-2521 08-49-25 28-10-2521 09-49-25	Detelgrofie 41.7 MB 100.4 MB Detelgrofie 88.8 MB 208.1 MB	
I	Daten der Grundwassermessstellen in NRW als CSV Datel Detei Deteil Daten der Grundwassermessstellen in NRW als Sgilte Datenbank Datei OpenHigstoC_gw-messstellen-insowene_EP9525652_Sgite.zp OpenHigstoC_gw-messstellen-insowene_EP9525652_Sgite.zp OpenHigstoC_gw-messstellen-insowene_EP9525652_Sgite.zp Grundwassetabhängige LandSkosysteme in NRW als Stape Datei	Letzte Anderung 28-10-2521 08-48-00 28-10-2521 08-49-06 Letzte Anderung 28-10-2521 08-49-26 28-10-2521 08-49-26 28-10-2521 08-56-11 Letzte Anderung	Datekgröße 41.7 MB 100.4 MB Detekgröße 86.8 MB 208.1 MB Detekgröße	

After extracting the above zip file then we can consider the four CSV files and instruction file which is highly recommended to read first.

2.3.2 Python

Python is an object-oriented programming language that helps the programmer to write logic and clear code for small as well as large projects.

Python is used in several ways such as:

- AI and machine learning
- Data analytics
- Data visualisation
- Programming applications

In this project, we have used Python for data engineering, data pre-processing and data analysis. Jupyter Notebook is used in this project to write python codes. The Jupyter Notebook is an opensource web application that data scientists simply can write the code and make it easier to document it. Simply we can combine python codes, text, images, comments and the result of the codes on the same page. The below image shows how code, text and the result of the code can be seen on a single page.

1000			1 A A	120101		1.00						In the second		
Filo	Edit V	/iow In	sert Cell	Kernel V	Magets	Help					Trunnets	Python 3 O		
图 +	9< tV	15 +	🔶 🕨 Run	E C »	Markdown	III								
		Read t	he file		>	Text								
		Don't forge	t to add the "de	limiter", norm	al csv file's	delimiter is "," but in	our case it's *;*,	, so we need	to assign it.					
	_													
In	Isel-	if = nd.r	ead csulaw s	tation ofna	me, deli	siters': headers	"infer")	L						
In	1 [59]: d	if = pd.r if.head()	ead_csv(gw_s	tation_pfna	une, deli	miter=';', header=	'infer')			Python Code				
In Ou	r [59]: d d	if = pd.r if.head() sl_mr	ead_csv(gw_s messstelle_id	tation_pfna	ome, delin •32	n32 gw_stockwerk	'infer') grundstueck	gemeinde_id	gwhorizont_id	Python Code gwhorizont	., beobachtung_v	wasserstand	-	
In	59]= d d it[5 <u>9]</u> = -	if = pd.r if.head() si_nr 0 67530	ead_csv(gw_s messstelle_id 32505929	tation_pfna name UWB-Ddorf 01285	•32 343064 5	n32 gw_stockwerk	'infer') grundstueck	gemeinde_id 05111000	gwhorizont_id NaN	Python Code gwhorizont NaN	beobachtung_v	wasserstand	٦.	
In Ou	n [sə]ə d d nt[sə]ə ə	if = pd.r if.head() sl_m 0 67530 1 51044	ead_csv(gw_s messstelle_id 32505929 10446746	tation_pfna name UWB-Ddorf 01285 600P012303	•32 343064 9 292077 9	niter=';', header= n32 gw_stockwork 578019 1.0 545349 NaN	'infer') grundstueck privat	gemeinde_id 05111000 NL000882	gwhorizont_id NaN S	Bython Code gwhorizont NaN Zwischenmittel	beobachtung_v	wasserstand -	₽	R
In Ou	n [59]: d nt[5 <u>9]:</u> -	df = pd.r df.head() sl_mr 0 67530 1 51044 2 51070	ead_csv(gv_s messstelle_id 32505929 10446748 87005323	tation_pfna name UWB-Ddarf 01285 60GP012303 588P024600	•32 343064 9 292077 9 287141 9	niter=';', header= n32 gw_stockwerk 578019 1.0 545349 NaN 884535 NaN	"infer") grundstueck privat	gemeinde_id 05111000 NL000882 NL001640	gwhorizont_id NaN 5	Python Code gwhorizont NaN Zwischenmittel Neurather Sand	beobachtung_v	wasserstand - -	₽	Ri

2.3.3 Anaconda

Anaconda is an open-source distribution for python and R. It is used for data science, machine learning, deep learning, etc. With the availability of more than 300 libraries for data science, it becomes fairly optimal for any programmer to work on anaconda for data science Anaconda is used in this project. An environment on Anaconda has been created to install all the packages needed for this project.



Environment in Anaconda: A conda environment is a directory that contains a specific collection of conda packages that are used in the project.

How to create Conda environment: The below video shows how to create a Conda environment, how to activate it, how to install different packages on the environment and how to deactivate the environment.



Python packages: a package is a collection of modules that have the same aim together. These modules are like functions and can help us to write code easily. The packages which are needed should be installed and imported before use.

To get more details about conda environment, I highly recommend visiting the below webpage.

https://towardsdatascience.com/manage-your-python-virtual-environment-with-conda-a0d2934d5195

openhype environment: In this project, openhype environment has been created in order to install all the necessary packages which are needed. openhype environment has been created based on the above video.

Several packages are related to data science but in this project, we have used the below packages. There are two ways to install the below packages:

install a package manually: In this way you need to install each package manually into openhype environment by the command prompt.

• **pandas:** pandas is one of the most important and popular packages of python among Data scientists for data manipulation and analysis. We can do Data cleaning, Data pre-processing, fill the data, visualize the data, Data inspection, Loading and saving data and much more.

In this project, we have used pandas, to read the CSV files, clean the data and do data engineering. The below code should be written into the openhype environment on Anaconda prompt

conda install pandas

• **sqlalchemy:** SQLAlchemy package is like a bridge between python programming language and database. we have used this package to connect to our database.

conda install sqlalchemy

• **psycopg2:** With the help of this package, our python program can communicate with the PostgreSQL database.

conda install psycopg2

• **geopandas:** With the help of this package we are able to work with geospatial data in Python. according to the geopandas website " It

is extends the data types used by pandas to allow spatial operations on geometric types".

```
Last update: 2023/01/05 14:38 eolab:openhype:start https://student-wiki.eolab.de/doku.php?id=eolab:openhype:start&rev=1663579549
```

```
conda install --channel conda-forge geopandas
```

```
conda install jupyter notebook
```

All the above packages must be installed into the openhype environment with Anaconda prompt.

Load all the packages into the environment by a yml file: In this way, you need to create an environment (which in our project is Openhype) and load a yml file which consists of the all packages that are needed for this project. The below image shows the content of our openhype.yml file.



With the below code, we are able to create an environment based on the yml file. Please be aware that this yml file should be in the same directory as our anaconda directory, otherwise you need to write the full path of the file. openhype.yml can be found from here

conda env create -f openhype.yml

How to create a yml file for the environment: With the below code you can export the yml file from the existing environment.

conda env export > openhype.yml

Since we have downloaded the four CSV files in the previous chapter, now is the time to read our CSV files and start to clean them in order to make them ready to import to our database.

please refer to our Notebook section of the code on Github (the below image).

```
2025/08/20 02:40
```

9/20

Search or jump to	Pull requests issues Marketplass	Explore			6-
E sina7272 / LANUV_Groundwate	r (Balla)			St. Ans ⊕ Unwardsh 1 + 🖤 🔶 Stavend ()	
O Code 🔅 Issoer 🔅 Pull requests	⊙ Actions ⊞.Projects 📼 V	Via © Security ⊨≤ Issights ©	Settings		
	P man - P trench Q0		Go to file Add file - Code -	About ()	
	stra7272 update		artifit 2 bean ago 🔞 22 comme	Ground water in NRW	
	 Joynb, checkpoints 				
	Matebook				
	🖿 data			V 0 torks	
	🖿 (978)			Beleven	
	D glamibates			To plane whited	
	D README.md			Excelsion Contemporation	
	READMEntd			Packages	
	LANUV_Groun	dwater		Na padagat padilahat Padalah yaur fini palakaga	
	Ground water in NRW			Languages	
				Suppore Routinesis 51.575 (# 1006.6755	
	(-) 0.002 (restrict). Terri	Pavely Storety Status Dor	a Cantal GRMub Prong JPI Transing	Bog About	
		ima	age 5- Github		

There below four notebooks should be run separately, in order to import data into the database.

- import_gemeinde.ipynb
- import_katalog_stoff.ipynb
- import_messstelle.ipynb
- import_messwert.ipynb

2.4 Observation Data in the Database

In the previous section, we have downloaded the data, cleaned and imported them to the database successfully and now it's time to see the data in the database. as we know, the SQL command is valid in the Postgres database, as a result of that, we will run some basic SQL commands to see the data.

First, we want to see our tables, with the below code, we are selecting all the columns (* means all the columns) from our schema which is consist of our table (in this case is **sina**) and with the name of the table. and then because the size of the table is huge and we want only to see the first 100 rows then we just limit it to 100.

select * from sina.messwert limit 100;

The below image (image 7) shows the result of the above command in PGadmin.

Last update: 2023/01/05 14:38 eolab:openhype:start https://student-wiki.eolab.de/doku.php?id=eolab:openhype:start&rev=1663579549

	5 III 1 Q	Dashboar	d Pr	operties	SQL	Statist	ics Dep	endencies	Dep	sendents	ß	etwas/etwa	is@alv	vas *											
	X 🚯 Domains		8	- 8	Q ~		1.6	8 2'		r 🖂	Nol	init. 🛩		• •	4 0		5 5	d'	*	18.×					
	Green FTS Configurations	de sina	d/ofws	ogeina																					
	PARTS Dictionaries	Query Edit	tor C	Juery His	tory																Scratch	Pad		_	
	FTS Templates	1	art i	from			linit	1001																	
	El Foreign Tables	1 964	eee -		5 million	oomer (courte	2001																	
	b) Functions																								
	> 🥂 Materialized Views																								
	V) Procedures																								
	 C1 Sequences 																								
	 Tables (6) 																								
	3 mgw_stations																								
	> matanog.ge																								
	A Contraction of the second second																								
	> messatelle																								
	> E messaert																								
	> by Trigger Functions																								
	 турна 	Data Outp	art E	xplain	Message	88 NO	dification	G																	
	🛩 🧱 Views (7)	sta	RF .	1 110	esstelle_id	1	pia.id	, datam.ph	1	stoff_re	1	probeegut	12	essergeb	nia.e	10	essergebni	a,hirwei	1	bestimm	ungsgrente	1	massembelt	1	treneverfa
	groupby_station_result	# IPK	1 milius	ting.	pot .		sort	date		Degint		Seat	- 10	ongale lauec	3800	16	et			contae la	ectation		tent	-	beat
	> instruk	1	1228	9051	299	102710	3/1992/16	1992-05-2	B		1244	Brundwasser	<u>د</u>		105	248 (1)	ALL .					pane.	mg/i	_	Mempran
	 Initial_geon 	2	1220	9063	2894	302910	1/1994/15	1998-03-2			1244	Grandbulkiter			d1.	978 29	10					Inte	mg/i	_	Membran
	> E Countie	3	1228	19272	803	900097	3/1093/36	1993-01-1	1		1244	Grundwasser			30	038 [11	4					1mg	ing/i	-	Membrant
	3 Te Tristers	4	1228	9077	803	900303	3/1992/16	1992-11-0	12		1244	Orundwasse	r.		2.25	777 19	A)					1rug	mp/i	_	Menibran
	> suffat	5	1228	/9070	803	100303	3/1993/16	1993-12-2	2		1244	Grundwarsser			3.05	463 (n	41					11/10	ngd		Metribrant
	> cs sulfat_geom	6	1328	/9081	803	300515	3/1092/16	1092-04-2	11.		1244	Grandwarost	·		11.0	675 (11	11					1410	mg/l	-	Membrant
	> Comp	7	1228	0097	803	300364	3/1093/16	1993-07-1	9		1244	Grundwasser			106	248 [n	#]					(mill)	mg/l		Membran
	> centerop2	8	1228	19099	BCS	900389	3/1002/16	1092-06-1	a		1244	Grandwasser	ŕ		53	124 (11	11					144E	ngd	,	Membrant
	(tiger	9	1228	19105	803	300418	3/1992/16	1992-07-1	4		1244	Grundwasser			9.7	994 (n	81	4	Succes	tuty part.	Total query	netio	ne: 230 msei	100	rows att
	🛞 liger_data	_		_		_				_	_					_	-	-			100			_	
*																									

Now with the above SQL command, we are able to see the others three tables that we have (The below codes).

select * from sina.messstelle limit 100;

select * from sina.katalog_stoff limit 100;

select * from sina.katalog_ge limit 100;

Now we want to see more details for our tables and we will run the below codes.

Count the rows of each table: with the below code, we can see how many rows we have in each table.

```
select count (*) from sina.messwert;
```

```
select count (*) from sina.messstelle;
```

Filter the data based on Nitrate only: In this case first we need to find out what the substance number of the Nitrate is. With below code, we can find

select * from sina.katalog_stoff where name like 'Ni%';

	5 5 8 - 10 Q - 8 - 5 8 2 - T - Inter - 8	6 0 1 5 5 d' A 8-
+ () Colston	Ø stemsteandeten v	
· ···	Query Differ Query History	Scritch Parl
> (), FTS Configurations	A side of the second se	
 ID FTS Dictionaries 	1 BECKEL 4 FTER BITS MEES COR SCOTT ATER THE LOSE HTT	
 Aut FTS Patients 		
a MP Forming Tables		
* Bit Functions		
< Contraction and Market		
 CProcedures 		
+ 1.1 Sequerices		
- El facier (6)		
 Interview as 		
> Illications stuff		
> El riespuramenta		
* mirrennrisie		
+ III messivet		
 B) Tripper Functions 		
 D Types 		
- revolution address cound	Dete Output Explain Messages Notifications	
s nitral	statur a terms a beachedurg a cet.M	
- Initiat_accm	A leger - hert - double precision - hert -	
+ The Columna	1 1143 Nos pull 744-051	
4 mm Rubert	2 THE NOW OUR MODE	
	I 1244 mm politica	
+ 2+ thiggers	TALL TRUCK CONTRACT TALL TRUCK	
+ 2+ Miggers + 2 suitet		
2+ friggen subst subst subst	5 T244 Herei	
+ 2+ friggers + suffat + suffat, geors + suffat, geors + suffat, geors	5 1246 Mini (nd) (nd) 6 1247 Mini (nd) (nd) 9 1247 Mini (nd) (nd)	
2+ triggens	5 1244 Hers [Hol] Hol] 6 1347 Hers/Sectem# [Hol] Hol] 7 1947 Nonsoverler Trease [Hol] Hol] 9 1947 Nonsoverler Trease [Hol] Hol]	
+ 2+ triggers suitat suitat suitat.porn suitat.porn suitat.porn suitat.porn suitat.porn v torn;2 v do torn v do torn;	1244 Hem Hell	
 > 2x Hopens > astat > wetd, poor > Werps > terp2 > > top top > > top uses 	5 T244 Hem	
	1 1244 Herri Holl Holl Holl 0 1247 Herrid Scient? Holl Holl Holl 7 1146 Holl Holl Holl Holl 8 2029 Horsberge Holl Holl Holl Holl 8 2029 Horsberge Holl Holl Holl Holl 9 2030 Horsberge Holl Holl Holl Holl 10 2021 Horsberge Holl Holl Holl Holl 10 2021 Horsbergegeber (Hral) Holl Holl Holl Holl	
 2n triggens antat instation 	S T244 Hem Hum Hum <thhum< th=""> Hum Hum</thhum<>	
2+ fliggens antat antata	5 T244 Hem Hem <td></td>	

As we can see in image 8, the substance number (stoff_nr) of Nitrate is 1244

Filter the data based on Nitrate only:

select * from sina.messwert where stoff nr = '1244';

Now we can filter the messwert table based on Nitrate. In this step we need to somehow save the above table. We can save this new table as a new "view".

What is views: A view is a database object that is of a stored query. A view can be accessed as a virtual table in PostgreSQL. It means that we can do whatever we are able to do with views same as tables. The below code create views for us:

```
create view sina.nitrat as (select * from sina.messwert where stoff_nr =
'1244');
```

Now we have "nitrat" view which simply can call same as tables with the below code. This view is filter of our messwert table based on "1244" which is "Nitrate"

select * from sina.nitrat ;

Group by the two tables: In this section we want to group by our two tables (messwert and messstelle) only in Nitrate. These two tables have a column **messstelle_id** which simply means station id.

```
select messstelle_id, count(*) from sina.messwert where stoff_nr = '1244'
group by messstelle_id;
```

. 8 .	🖀 🔍 Deathcard P	Properties 908.	Statistics: Dependencies: Dependents 🚮 elwaulelwan@alwas.*		
 W DOBIC 		- II Q	8-6 E #- T	(m.)	
- 0.004	SPACE PROPERTY IN				
+ D. Constants	E. all interpolation	Conception of the local division of the loca			
A D. FTI Conferentiant	-Crimità Ergazia	Query Hatory			Scratch, Peel
A Dis ETIL Discovering	1 select	repostelle, to	count(+) from sine.mesowert where stoff_rr = '1244' group by messatelle_id		
 Av FTS Parsers 					
+ CFTS Templates					
 III Foreign Tables 					
+ No Punctions					
+ 😸 bitaterialized Views					
+ U)Procedures					
+ 1.1 Sequences					
- III Tabies (0)					
 III gw_stations 	1 m m				
s Ithateog.ge					
> mikatalog_stoff					
 Its measurements 					
• III mainifalle					
s III metawen					
 Indok contractory 					
- Wees (T)		202020100000			
a group station would	Cara Orthet	Explain Neas	8. NO15049913		
+ critrat	theory of	dalid a real	a		
- Cuttat_peom	A 1991	- spe	2		
+ 🛅 Column		10131210			
e 💼 Rules		10200400			
+ 2+ Tiggers		18290411	28		
> interest of	10 th 10	(3200691	3		
>sufat_peore		10200710			
* Tomp	4	18280808	17		
* entrol	- T -	1220/9442	4		
 Optiger 		10301038	4		
s to tope_chata		18281917	0		
> @ mpadge	18	10201262	n		
b Towards outer	11	(8281294	2		
5 Theorem	12	10201306	a la		
dia Login/Tenug Roles	18	10201312	4		search do not work many sustains with most "they came affect
and second of the second	A second se			1000	Semanary rate room which requires to contract them in any

Image 9 shows that each station id has how many single measurements for the Nitrate only. I highly recommend opening the below website to get more deep into how "group by" works and how we can use it.

https://www.w3schools.com/sql/sql_orderby.asp



Maximum date in nitrat table:

```
select * from sina.nitrat where datum_pn = (select max(datum_pn) from
sina.nitrat);
```



As we can see in Image 10, the maximum date is 2021-08-17

Minimum date in nitrat table:

```
select * from sina.nitrat where datum_pn = (select min(datum_pn) from
sina.nitrat);
```

a and a second s	🎹 🐂 🔍 Dashboard Properties 203. Etablicius Dependencies Dependencies 👩 elway/elwast/		8
 se pated 	S & B Y E D Y B Y E B BY T Y THE Y E B Y A D Y S S AY A BY		
·			
+ S.Conatione	Construction of the second sec		
 BUTT Contractions 	Overy failor Overy failors	Soutch Pad .	,
 M FTS Dictionaries 	3 select + from wine, mitrat where dotum_pn = (select minidatum_pn) from wine, mitrat);		
+ #4 FTS Paraelo			
 FTS Templates 			
> III Foreign Tables			
 BiFunctions 			
 Other Mathematical Views 			
> \$1Procedures			
 1.3.Sequences 			
- CTabres (S)			
 Engles_dations 			
 Imitiation shall 			
 Immenostate 			
+ III measured			
> 89 Trigger Functione			
> C Types			
- 📫 Viens (7)	Data Output Explain Messages Notifications		
+ proupto_atation_result	al ar massada id una id datem an endfor understot massadated o tassadated binesis bettern toposets massadated to	performent of the best of	n and the
+ etat	a tiger to taget to tage to taget taget to taget	ther the base there	·
e atal_geon	1 1221403 10212142 5/195/30 10226430 10244 Sundaware 1.6499 (uii) (uii ng) (interrupted)	pull HYDE,	88-K 2011-09-28
> Econter			
a the Thismann			
a the second			
+ mattat.goinn			
+ Charge			
+ interact			
* -@rtgar			
 -@-tger_data 			
 Is fopology 			
 Im postgrep 			
> Entertrate Troutin			
 An important intervention 			
Statistication			
h in the second second			

As we can see in Image 11, the minimum date is 1951-04-30

Create geometry column in messstelle table: In this section, we want to create a geometry column from **e32** and **n32** columns from the messstelle table. with the below code, we are able to create a new column and we set the name as **geom**

```
ALTER TABLE sina.messstelle ADD COLUMN geom geometry(Point, 25832);
UPDATE sina.messstelle SET geom = ST_SetSRID(ST_MakePoint(e32, n32), 25832);
```

```
Last update: 2023/01/05 14:38 eolab:openhype:start https://student-wiki.eolab.de/doku.php?id=eolab:openhype:start&rev=1663579549
```

	5 III % C	L Dashbo	ard Propertie	s SQL Statistics De	ependenci	es Dependents	a elwas	s/etwassjoetwas *							1
2.5	8 public	8 9		Q - # - %	8 0	8- T - N	finiti		4.0		đ	* # 18*			
* 4	🕑 sina	45 etc	as/olwas@elw	25 V		A REAL PROPERTY.		-		-		() () () () () () () () () () () () () (
	> [] Collations	Duery E	ditor Duery H	Istory									Scratch Pad		14
	B FTS Configurations		Jack & from	also anno 11											
	> DA FTS Dictionaries	4.1.94	THEFT TITLE	STHA-BESSACELLA											
	As FTS Parsers														
	FTS Templates														
	Foreign Tables														
	> 40 Functions														
	Procedures														
	> L3 Sequences														
1	→ El Tables (6)														
	> mgw_stations														
	> Hatalog pe														
	> 📰 katalog_stoff	Data Ou	put Explain	Messages Notification	118										
	the state of	Data Ou	for Explain	Messages Notification	10	usbeudurchmesser.mm		historischer ruhe wap		embaulaence.cm		oberkante, filter, om	o unterkente filter om		98001 o 679
	tikatalog, stoff timessurements. timessutelle timessutelle	Data Ou	fibrisenge_cm double precision	Messages Notification	ns A a	oubeudurchmeasur, mm ouble precision	۵	historischer, ruhe, wep double precision		embaulaengecm double precision		oberkante, filter, om double precision	a unterkante_filter_cm double precision		geometry
	katalog_stoff imposurements imposurements imposurefie imposwert Withrigger Functions	Data Ou stor	fiberlaenge,cm double precision	Messages Notification	na 6 🔺 Jiuri	uabeu Jurchmeaser "mm Iouble precision	A [tut]	historischer, ruhe, wap double precision	A [1.1]	embautaenge.cm double precision	A (5-0)	oberkante, filter, om double precision	unterkante, filter, cm double precision [nul]	A but	geometry A Discontinue
	Hatalog_stoff Immeasurements Immeasurements Immeasurement Working Functions Working Functions Types	Data Ou ster A N media. t Padetta.	fput Explain fiterisenge,cm double precision	Messages Notification a sumpfishrienge.cm double precision inuli 1000	en 6 A Fluct Jhurt	oubeudurchmesser.,mm ouble precision	(judi) 110	historischer, ruhe, wap double precision	ه الدرا الدرا	eirbaulaanga,.cm double precision	4 (1-58) 2000	oberkante, filter, om double precision	unterkante, filter, om doeble precision (null) 10349	4 (nul) 9349	geometry Geometry 10101000020EB640 0101000020EB640
	Hatalog_stoff Immasurements Immasurements Immasurement Workinger Functions Workinger Functions Werks (7)	Data Ou sber A Nimedia. 1 Padeth. 1 Debru.	fput Explain fibriange.cm double precision	Message Notification astrophysical action built toto juli	ns 6 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	oabaudurchmeasar, mm ouble precision	(null) 110 (null)	katorischer "ruhe "wap double precision	(1.1) (1.1) (1.1)	etribuulaanga,.cm double precision	4 (hot) 2000 (hul)	oberkante, filter, om double precision	unterkante, litter, om doctie precision (null) (null)	4 5-00 9349 (5-01)	geomity Geometry Geometr
		Data Ou ster	fput Explain fiteriaenge.cm double precision	Messages Notification a sampficiktuenge, em double precision (hull (hull (hull	Bandina Sana Bandina Bandi Bandi Bandi Bandi	onbeuðarchmesser, mm ouble precision	(nul) (nul) (nul) (nul)	Bistofischer, nuhe, wap double precision	(10) (10) (10) (10)	embiouflaengecm double precision	(1001) (1001) (1001) (35)	oberkante, filter, om double precision	unterkanta, fiter, on double precision [null] 7805	(hull) 9349 (hull) 7505	geometry geometry 0101000020E8640 0101000020E8640 0101000020E8640
		Data Ou ster	fput Explain filterisonge.cm double precision	Messages Notification ampfohrhonge.cm (0.00) (0.01)	B B B Bud Bud Bud Bud Bud Bud	usbudurdmesser,mm ouble precision	(rul) 113 (rul) (rul) (rul)	Natoriacher, nuñe, wep double precision		einbisufaengecm double precision	(1000) (1000) (1001) (1001) (1001) (1001)	oberkants, filter, om double precision	anterkante, Star.,em dosble precision (null) (null) 7505 (null)	(huit) 9349 (huit) 7505 (huit)	geometry
	* ** *** *** ******	Data Ou siber A Nimedia. I Padetta. I Datau. Susterpl. I Dasaul.	Aput Explain Antiaenge.cm double precision	Messages Notification ampfishtuenge.cm double precision 1000 (vul) (vul) (vul) (vul) (vul) (vul)	Bank Bank Bank Bank Bank Bank Bank	oabeadurchmeaser,men ouble precision	(nul) (nul) (nul) (nul) (nul) (nul)	hatolacher, uhe, wsp double precision	(101) (101) (101) (101) (101) (101)	einbeulaengecm double precision	(mail) (mail) (mail) (mail) (mail) (mail) (mail)	oberkants, filter, om double precision	unterfeater, Star.om double precision louil louil	(hul) 9049 (hul) 7505 (hul) 3452	geometry Image: Construction of the constructi
	Set Natolog_stoff mosaurements Trossatelie Set ressuent Toger Functions Toger Trope Trope Trope Trope Trope Set Trope Trope Set Trope Trope Set Tro	Data Ou iber A Nimedia. 1 Padetta, 1 Dataut. 1 Dataut.	rput Explain fiberisenge, om double precision	Message Notification assignment of the state	en b b but fuct fuct fuct fuct fuct fuct	aabaadunchmeasaar,mee	(rul) (rul) (rul) (rul) (rul) (rul) (rul)	hatorlacher, ruhe, verp double precision	100 100 100 100 100 100 100 100	einbustaenge, om double precision	(mall) 2000 (mall) 635 (mall) 900 815	oberkante, filter, om double grecision	destination, Bitor, con desting recision //ull //u	(hull) 9349 (hull) 7505 (hull) 3452 3160	gedes georetry ▲ 0101000020E8640. 01010000020E8640. 0101000000E8640. 0101000000E8640. 010100000288640. 010100000288640.
	Set Natolog_stuff Set measurements Tropsatelle Set measurements Tropsatelle Set Tropse Venus (7) Grupostry_station_result Ontal Columns Set Colum	Data Ou ster A Ni media. 1 Pasetta. 1 Delbriz. 5 ueterst. 1 Disset. r Layerk.	Aput Explain Aburtaenge, am double precision	Messages Notification assignational assignation of the second subscription of the se	Bard Bard Bard Bard Bard Bard Bard Bard	unbiso and measure , me outrie precision	(null) (null) (null) (null) (null) (null) (null)	historiacher, n/ha, wsp double precision		erchautenge.cm double precision	2000 (null) 635 (null) 900 815 1563	oberkante, filter, om	deuterkante, Star, em deuter precision [nul] [nul] 7505 [nul] 3452 3150 5668	(hul) 9349 (hul) 7505 (hul) 3452 3150 3068	geometry Image: Construction 01010000020E8640 Image: Construction 01010000020E8640 Image: Construction 01010000020E8640 Image: Construction 0101000020E8640 Image: Construction

Now the messstelle table has one more column (geom) which consists of the geometry information of the location of each station.

Merge two tables:

In this section, we want to merge the two tables (messwert and messstelle) based on the same column which is "messstelle_id". We need to select columns that we need from each tables and then merge them based on the "messstelle_id"

```
select t1."messstelle_id", t1."name", t1.geom, t2."stoff_nr",
t2."messergebnis_c", t2."masseinheit",
t2."datum_pn", t2."messergebnis_cm" from sina.messstelle t1 , sina.nitrat
t2
where t1."messstelle_id" = t2."messstelle_id";
```

 W public W sime 		9 ~ II Q ~	9 - 5 8	Ľ'- T -	10000 - B.F	* * 8 *	5 5 4- 4	1 (R)
* §1 Collations	Road Street	and the second second						
 By Domains By PTS Configurations By PTS Configurations By PTS Configurations By PTS Configurations By PTS Tomphotes By PTS Tomphotes By Paradisms By Paradisms Configurations Contactions Contactions Contactions 	Compilation	QueryHenory 2 11. "menutulla_ Mour.pe", 22."mess 1 11."menutalla_5	NC, t1."rame", sengetoris_cer" f f" = t2."senant	tigeon, t2;" ree statuets alla_ta";	stoff_po", 12."manarg stellm 11 , sina.nitro	părta_c", t2,	hammerichett",	Scranth Field
* minutatiog_excet	Data Ordant	Familian Messagers	Netton					
Eliterendelle Eliterendelle		tootalia, id a suma a	pone +	107.0 A 700	ergeben.c e massachet	a teaman	a manangabria.cm	•
+ BUTiloger Functions	1	UNIOCTIV BORNE.	0101300003068840	1344	100.249 (mpl)	1890-09-22		
+ 🐑 Typen	1	HOROZOFI HAHAL	010100003053840	1344	AQ.0960 (mp.4	1892-01-88	142	
		ROBORTSI HATHRI.	DED DOUTING THE R.	1244	strath (with	1094-0111		
* Stransby_station_real	1.1	8000217W STEDE	or or an occidentation.	1244	44.07 1994	1910-02-04	(#)	
F Stretter	. 5	10102178 17006	onersossepekk.	1244	4437 stg8	1990-07-15		
* Stratut geom	. 6	\$0002178 STEGE	01010003200340	1344	-40.3846 mg/l	109440-10		
a El Coloma	T	250000111 Hidron.	01010000008940	1344	binth mpt	1806-09-15		
× (0176240)		BITMENE WOOS-	OPTIMOTOESE40	1344	10.81214 (mp.f	180410.08	In grant the second	
S Te Telepera.							A SHOOMSPARE	et, sonal-query tarticise, i secol 480 marie: 33899 rows allo

Now we need to create a view and save this SQL command as a new view. the name of this new view is "nitrat_geom".

create view sina.nitrat_geom as (select t1."messstelle_id", t1."name",

```
t1.geom, t2."stoff_nr", t2."messergebnis_c", t2."masseinheit",
  t2."datum_pn", t2."messergebnis_cm" from sina.messstelle t1 , sina.nitrat
  t2
where t1."messstelle_id" = t2."messstelle_id")
```

We need this new view for the next section in QGIS.

2.5 QGIS

QGIS is an open-source and free application that can support viewing, editing and analysis of geospatial data.

You can download QGIS for free from the below link.

https://qgis.org/en/site/

The below video shows how to download and install QGIS for windows which are highly recommended to watch before installing it.



Now is the time to get to know about QGIS and the below video can help so much.



Create a time series video: In this section, we want to create a time series video to see how the nitrate concentration has been changed over time in North Rhine-Westphalia which is the most crowded state in Germany. First, we need to download the shapefile of the North Rhine-Westphalia state and load it into QGIS.

We will download three shapefiles,

• Whole state shapefile (dvg1bld_nw.shp)

- kreis shapefile (dvg1krs_nw.shp)
- Gemeinde shapefile (dvg1gem_nw.shp)

All the three shapefiles can be downloaded from here. After downloading, we need to load them to the QGIS to see them. The below video shows how to load the shapefile in QGIS.



Now we can see the map of NRW, kreis and Gemeinde. There are two options to create a video for time series.

Locally with shapefile: In here, we need to have a shapefile that consists of the nitrate concentration over time. download the notebook from here and run the python codes to create two shapefiles. then we should load these two shapefile to the QGIS. The first shapefile is consist of all stations in NRW and the second one is consist of the nitrate concentration.

The below video shows how we can load shapefiles to QGIS.



Connect to Database: The below video shows how we can connect our QGIS to Database and load the file.



3 Dashboard

This section will discuss how we can create an interactive dashboard for our data. An interactive dashboard is a tool that users can interrelate with data by analyzing, visualizing as well as monitoring the data.

Two approaches to creating a dashboard will be discussed in this section. The aim of this dashboard is a simple interactive dashboard in which users with no knowledge of programming can easily consider the data as well as a map. This kind of dashboard will help users to understand data better. Nowadays dashboards are widely used in several ways to help managers and decision-makers to make decision easier. one good example of such a kind of dashboard is the Covid-19 dashboard which each country also here in Germany people are widely used. The Covid-19 Dashboard aids people in noticing how many new cases and how many new deaths have been recorded in different periods of time.

In our case, we want to create a simple dashboard which shows the map of NRW as well as Nitrate and Sulfate concentration rates at different times.

3.1 Plotly Dash:

Plotly: Plotly is a computing company located in Montreal, Canada. They develop online data analytics and visualization tools. Plotly offers online graphing, analytics, and statistics tools for their users, as well as scientific graphing libraries for Python, R, MATLAB, Perl, Julia, Arduino, and REST. Plotly offers several open-source and enterprise products such as Dash which have been used for creating simple and interactive dashboards in this project.

Dash: Dash is a framework to build data apps rapidly not only in Python but also in R Julia, and F#. According to Plotly official website, Dash is downloaded 800,000 times per month which shows that nowadays Dash getting more popular. Dash is a great framework for anyone who uses data with a customised user interface. With only a couple of patterns, Dash

Through a couple of simple patterns, Dash eliminated all of the technologies as well as protocols that are needed to make a full-stack web app with interactive data considerations. Another good feature is that Dash is running on web browsers so it means that no other application needs to run it.

If you would like to know more about Dashboard with Plotly Dash, click the link below.

https://www.youtube.com/c/CharmingData

Dash is also offering some dashboards examples which could be really nice and helpful to get ideas. | Click here for Dash gallery

All the source codes of the dash gallery are available in | here

3.2 Panel:

4. Result

Nitrate concentration 2000-2010

The below video has shown the concentration of nitrate in NRW from 2000 to 2010. The video is created with QGIS 3.16



Nitrate concentration 2010-2020

The below video has shown the concentration of nitrate in NRW from 2010 to 2020. The video is created with QGIS 3.16



Sulfat concentration 2000-2010

The below video has shown the concentration of sulfate in NRW from 2000 to 2010. The video is created with QGIS 3.16



Sulfat concentration 2010-2020

The below video has shown the concentration of sulfate in NRW from 2010 to 2020. The video is created with QGIS 3.16



5. Project codes

All the codes are available in below link.

Click here for project codes

Weitere Infos

• EOLab-Wiki-Seiten zum Thema Grundwasserdaten in NRW

From: https://student-wiki.eolab.de/ - HSRW EOLab Students Wiki

Permanent link: https://student-wiki.eolab.de/doku.php?id=eolab:openhype:start&rev=1663579549



Last update: 2023/01/05 14:38