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USING ENVIRONMENT TRACERS FOR INVESTIGATION OF SUBMARIN GROUNDWATER DISCHARGE

[1]George Melikadze, [2]Michael Schubert, [3]Christos Tsabaris, [1]Nino Kapanadze, [1]Mariam Todadze, [1]Zurab Machaidze, [1]Alexander Chankvetadze

[1]Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University
[2]Helmholtz-Zentrum für Umweltforschung GmbH – UFZ
[3] Institute of Oceanography,Hellenic Center for Marine Research (HCMR)

Abstract

The investigation of material transport via submarine groundwater discharge (SGD) is more challenging. In order to determine the groundwater discharge areas into the sea during studies had been implemented and selected the new methodology of using ecological tracers. During marine and land investigations studies had been successfully used the complex of ecological tracers – stable isotopes 18O and 2H, radionuclide Rn and Ra and other parameters. On the territory of Kobulety had been defined the groundwater flow direction and the areas of their submarine discharge. Within the identified areas was defined the intensity of eutrofication – the value of nitrate and phosphate content in groundwaters and in the sea. Also, had been studied their distribution on the surface and intensity of outwash into the sea.

1. INTRODUCTION

The sustainable management of the coastal ocean generally requires a comprehensive understanding of the processes related to solute and particulate material transport from the terrestrial to the marine environment. Whereas river and sewage discharge into the sea are bound to distinct locations, thus allowing straightforward quantification of discharge rates and material budgets, the investigation of material transport via submarine groundwater discharge (SGD) is more challenging. Adding to the general difficulties in locating and investigating groundwater sources on the coastal seabed is the spatial and temporal variability that is typical for SGD.

SGD provides a major potential pathway for solute and particulate transport across the aquifer/ocean interface. Nutrients and contaminants carried by the groundwater have a significant potential to cause deterioration of the overall quality of the coastal environment. Related detrimental environmental impacts include contamination and eutrophication of the coastal sea, contamination of seafood, coral reef damage, and harmful algal blooms.

Aqueous tracers provide an appropriate tool for investigating SGD. "Environmental tracers" are defined as natural or anthropogenic substances that are ubiquitously present in the environment originating from defined sources. In contrast to artificially injected tracers they have the general advantage of not contaminating the studied environment by introducing chemicals that may prove persistent into the water body of concern. In addition, due to their ubiquitous occurrence environmental tracers are most suitable for large-scale and/or long-term studies, which are essential for comprehensive SGD investigation.

The scientific aim of the "SGD Black Sea" research project was the application of a multi-tracer approach for SGD research at two exemplary sites on the Black Sea coast. It was the intention to combine several appropriate aqueous tracer methods for SGD localization and quantification and to confirm the achieved findings by a novel approach based on satellite data. The applied satellite-based information allow (i) a water flow accumulation modelling approach based on a terrestrial

digital elevation model (DEM) and (ii) an assessment of large scale and long term temperature patterns of the coastal sea. The two suggested study sites have been chosen in order to show strong exposure to anthropogenic pressure on the mountainous eastern coast of the Black Sea (Georgia).

2. DESCRIPTION OF STUDY AREA

Georgian team has collected all geological, geophysical, hydro-geological, hydrological and other data about study area. All data was digitized and created data-base (1,2,3).

The coastal zone of study area is located between confluence of river Kintrishi and Kelenderi cape (Sarphi). The coastal zone has a concave form. The coastal zone is built by the sediments transported by rivers. Sediments are distributed by the coastal sea flows –for the south part of study area sea flow changes its directions - from the south to the north. Along The mentioned coastal zone sea water mineralization is 12-17 % and at the confluences of big rivers it decreases till 0-10 %. This fact should be given much attention as we see that continental water flow takes an important part in hydrochemical regime of the coastal zone. It means that toxic and contaminative substances keep a high concentration for a long time. This fact was proved during the observations in Batumi and Poti in 1988-1990. From 1923-1925 due to global climate changing processes Black sea level is increasing. in 1875-1925 it was 40 cm. it should be noted, that the in 1925-2000 the water level increase was 18 cm.

3. DATA COLECTION

3.1 FIELD WORK ON THE GROUNG SURFACE

During the 2012-2013 on the territory of Adjara the field work along the coastline and the surrounding areas had been started. The main research goal was to explore and outline the contaminated areas along the coastline, which represent the potential sources of sea contamination. Along the coastline were sampled every kind of underground water outflow (river, spring, well and borehole). During field work the mobile group was moving by car, which was equipped with special devices (for Ph, conductivity, temperature, free oxygen as well as for Radon and Helium measurements). Besides, the selected points were sampled and the samples were shipped to the laboratory (Tbilisi) for further analyzing.

The sampled points were mapped by GPS and on the next step the data was processed by ArcMap. By the same software was mapped geological, hydrogeological and hydrochemical data. Above mentioned gave us possibility complex studies.

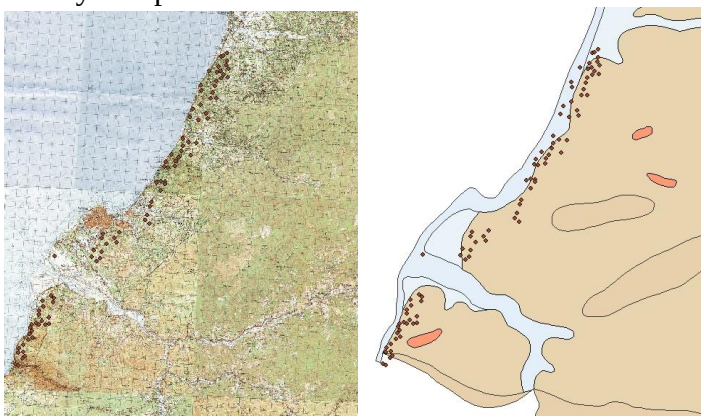


Fig. #1 Dislocation of sampled point on the Topographical and Geological map

Had been observed the radon and helium distribution (4, 5) and their background values as well as hydrochemical parameters (Na, Ca, K, Mg, HCO3, SO4 and Cl) in underground waters.

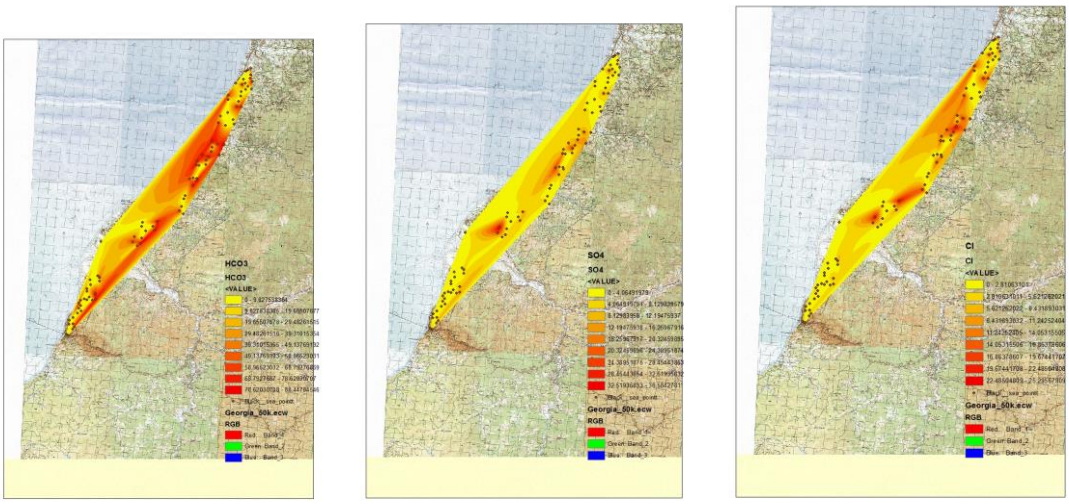


Fig. #2 Distributions of HCO_3, SO_4, Cl in the groundwater along the seaside
There are fixed some anomalies located Northern from Batumi and on the territory of Kobuleti

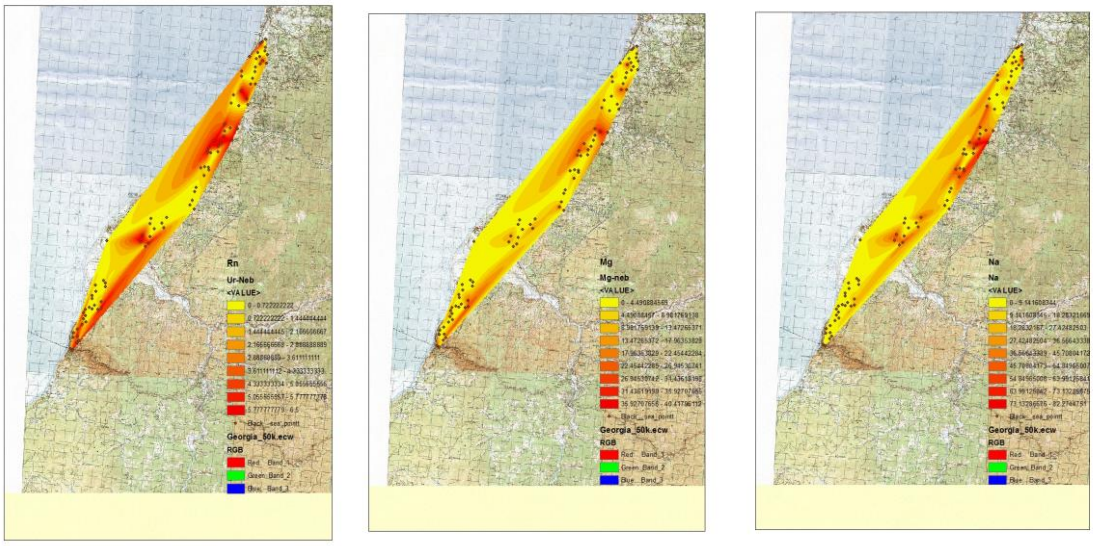


Fig. #3 Distributions of Rn, mineralization and Na in the groundwater along the seaside

During mapping arte fixed anomalies in the distribution of Rn in the groundwater. This zone consisted with anomalies zone of hydrochemical parameters. The observed anomalies may indicate on the polluted areas and represent the object of our interest for further detail studies.

3.2. MARIN SURVEYS

The preparation work for marine expedition had been done together with German colleagues. Namely, the satellite data processing was done by German colleagues. Had been processed and analyzed thermal background data of sea and ground surface.

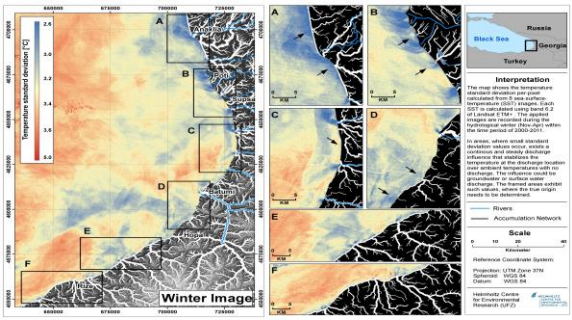


Fig. #4 Satellite data

On the picture shows the cold water discharge areas in the sea at the confluences of rivers as well as at the underground water discharge places. After analyzing two areas had been selected – the one North from Batumi and another one close to Kobuleti, where was expected to reveal the areas of underground waters discharge.

In September 2012 German colleagues arrived in Georgia. During their scientific visit the marine expedition in the Black sea coast was organized. There was done a profile From Batumi till Choloqi by boat and the water physical properties (conductivity, temperature and etc) and Radon concentration were measured continuously.

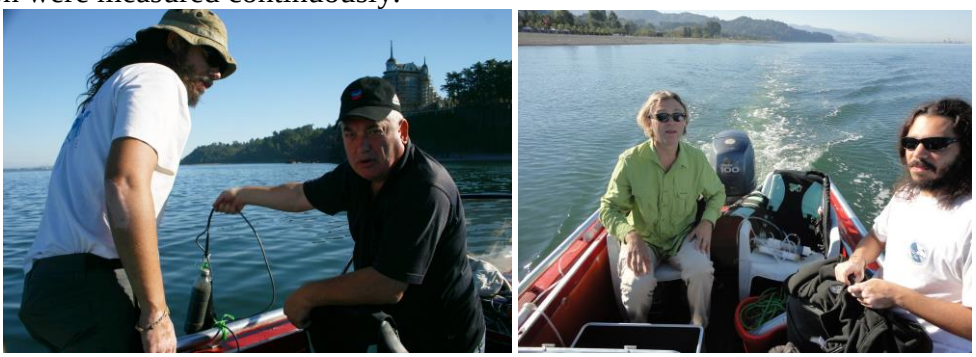
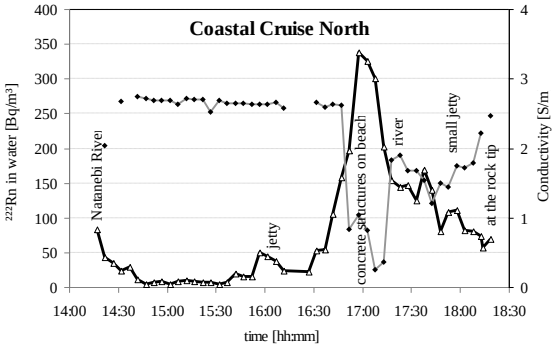


Fig. #5 Marin field study

Fig. 6 Illustrates the radon concentrations and the related salinities that were detected along the coastline and on the perpendicular profile. Fig. 7 shows the same information as diagrams.

Fig. 6A (left): Radon data recorded during the 1st sampling campaign in September 2012. The size of the circles corresponds to the detected radon concentration.

Fig. 6B (right): Salinities recorded during the 1st sampling campaign in September 2012. The size of the circles corresponds to the detected salinity values.



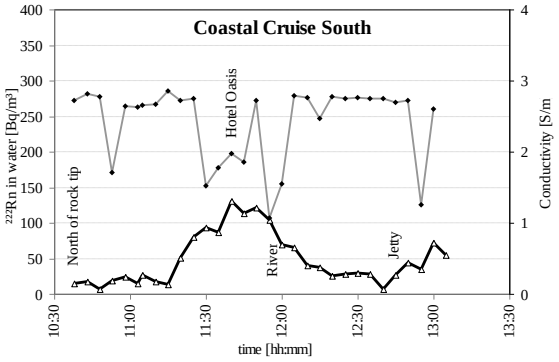


Fig. 7A (left): Radon and salinity recorded during along the northern part of the coastal survey in September 2012.

Fig. 7B (right): Radon and salinity recorded during along the southern part of the coastal survey in September 2012.

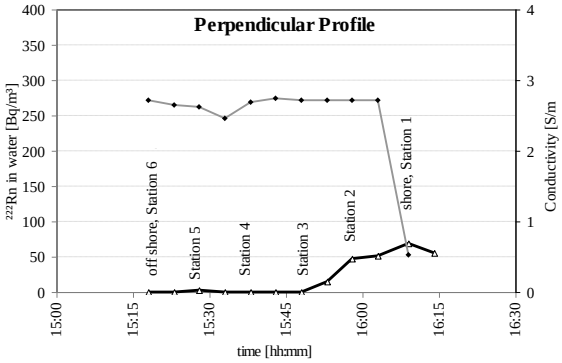
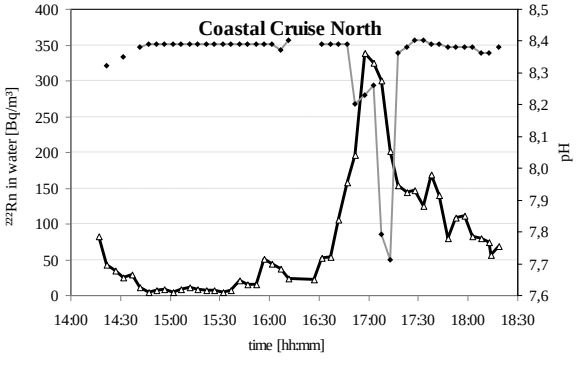


Fig. 7C: Radon and salinity recorded during along the perpendicular profile in September 2012.

As an additional parameter the pH of the seawater was recorded. As it becomes obvious in Fig. 8A the pH showed a distinct peak at the same location where elevated radon concentrations occur, indicating strong SGD. The data displayed in Fig. 8B, illustrating the findings along the southern part of the coastal survey, do also show a negative correlation between radon and pH, which is however not as distinct as the observation displayed in Fig. 8A.



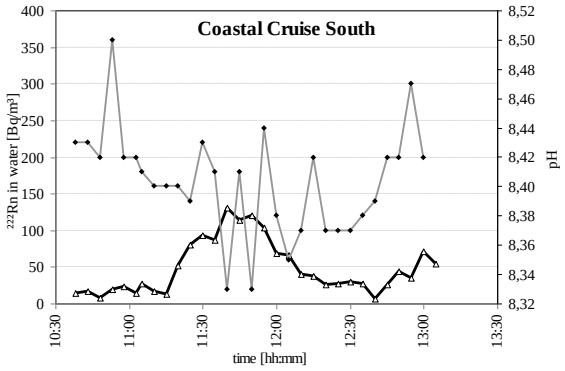


Fig. 8A (left): Radon and pH recorded during along the northern part of the coastal survey in September 2012.

Fig. 8B (right): Radon and pH recorded during along the southern part of the coastal survey in September 2012.

Along the perpendicular profiles also had been done sampling of stable isotopes – 18O and 2H in order to use them as additional tracers. The results showed that mixing of underground water with sea water occurs about 300 meters from the shore and the contribution of underground water is about 5 %. By The joint marine and land investigations showed that found anomalous areas can be identified as continuation of each other.

In order to determine the intensity of eutrophication (nitrate and phosphate pollution) had been measured the nitrate and phosphate content in groundwaters and sea water in areas of revealed groundwater submarine discharge. Their values are less than the allowable standard for nitrates and range from 0.2 - 3 mg / l and for phosphates 0.18 -1 mg / l.

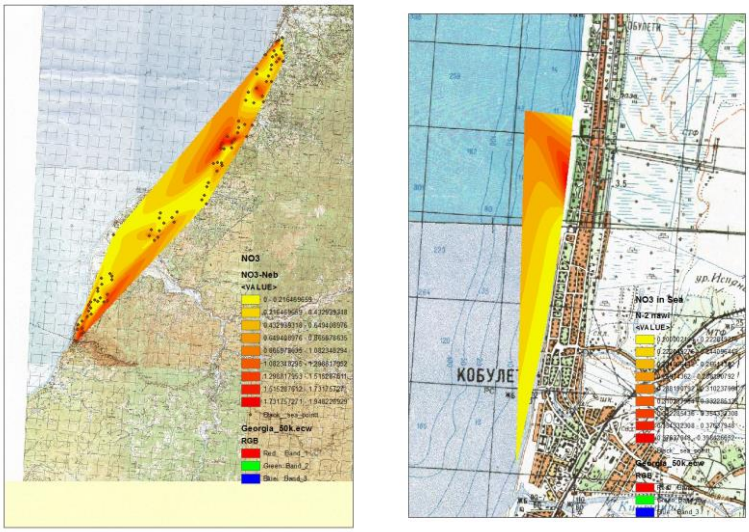


Fig. #9 Distributions of NO3 in the groundwater (left) and sea water (right) along the seaside

Despite the fact that their values are lower than the permissible limit in the sea water – fro nitrates 0.2 - 0.4 mg / l and phosphates of 0.02 - 0.04 mg / l, the amount of run-off of pollutants into the sea is significant. For example, the average annual discharge of Kintrishi river is 0.003 million. m^3, and the Chakvis-Tskali - 0.002 million m^3, which is for nitrates and phosphates 9000 tons per year to 3000 tons per year, accordingly for Kintrishi river and for Chakvi tskali river accordingly 6000 tons and 2000 tons per year. The mentioned tendency will decrease in time if the arable lands are not enriched by chemicals in future.

4. CONCLUSIONS

On the territory of Kobulety had been defined the groundwater flow direction and the areas of their submarine discharge; had been defined the surface character of contamination. Within the identified areas was defined the intensity of eutrofication – the value of nitrate and phosphate content in groundwater and in the sea. Also, had been studied their distribution on the surface and intensity of outwash into the sea.

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Использование экологических трассеров для изучения субмаринной разгруски подземных вод

Георгий Меликадзе, Нино Капанадзе, Мариам Тодадзе, Зураб Мачаидзе, Александ Чанкветадзе

Резюме

Изучение движение материалов по подводному стоку подземных вод (SGD) является сложной проблемой. Чтобы определить области разгрузки подземных вод в море во время исследования была выбрана и осуществлена новая методология- использования экологических индикаторов. Во время морских и наземных исследований был успешно применен комплекс экологических индикаторов: стабильных изотопов 18O и 2H, радионуклидов Rn и Ra и других параметров. На территории Кобулети было определено направление движения подземных вод и места их выхода (излива) на дне моря. В локализованных областях была определена интенсивность эвтрофикации – величина нитратов и фосфатов в подземных водах и в море. Кроме того, была изучена их распределение и интенсивность смыва в море.

ეკოლოგიური ტრასერების გამოყენება მიწისქვეშა წყლების სუბმარინული განტვირთვის შესწავლაში

giorgi მელიქაძე, ნინო კაპანაძე, მარიამ თოდაძე, ზურაბ მაჩაიძე, ალექსანდრე ჭანკვეტაძე

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მიწისქვეშა წყლების სუბმარინული განტვირთვისას მასალის ტრანსპორტირების საკითხის შესწავლა მეტად საინტერესოა სამეცნიერო თვალსაზრისით. ზღვაში განტვირთვის უბნების დასაფიქსირებლად შერჩეული და დანერგილი იქნა ახალი ეკოლოგიური „ტრასერების“ ტექნოლოგია. მიწისზედა და საზღვაო კვლევების პროცესში წარმატებით იქნა გამოყენებული ეკოლოგიური „ტრასერების“ კომპლექსი– სტაბილური იზოტოპების 18O და 2H, რადიონუკლიდების Rn და Ra ნაკრები. ქობულეთის ტერიტორიაზე გამოვლენილი იქნა მიწისქვეშა წყლის ნაკადის მიმართულება და მისი განტვირთვის არეალები. გამოვლენის უბნებში განისაზღვრა აითროფიკაციის სიდიდეები– ნიტრატების და ფოსფატების კონცენტრაციები ნიადაგში

და ზღვაში. ასევე, შესწავლილი იქნა მათი განაწილება ზედაპირზე და ზღვაში მათი ჩარეცხვის ინტენსივობა.