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Air quality on the Rhine and in the inland ports of Duisburg and Neuss –

Immission-side effect of emissions from shipping and port operations on nitrogen oxide pollution – Results from the EU Life Project „Clean Inland Shipping“ (CLINSH)

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The international EU Life project „Clean Inland Shipping“ (CLINSH) [1] deals with the influence of emissions from inland vessels on air quality and the effectiveness of various technical measures to reduce these emissions. Seventeen project partners from the Netherlands, Belgium, Great Britain and Germany are participating in the project, which will run until the end of 2021.

The North Rhine-Westphalian State Office for Nature, Environment and Consumer Protection (LANUV NRW) contributes to „CLINSH“ with detailed studies on air quality on the Rhine and specifically in the ports of Duisburg and Neuss, with a detailed analysis of the causes of pollution and with „real-drive“ studies of the effect of exhaust-technical measures on its laboratory ship under real operating conditions. The first results of these investigations can be found in the LANUV technical report 102 „Emission measurements on the laboratory ship „Max Prüss“ after equipping with an SCRT system“ [2]. In the following the results of the extensive investigations on air quality on the Rhine and in the large inland ports in NRW are presented.

1. Introduction

A good quality of breathing air is one of the essential foundations for human health. For this reason, the EU Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC) [3] set binding limit values for fine particulate matter (PM10, annual mean 40 µg/m³, a daily mean of 50 µg/m³ may be exceeded on a maximum of 35 days) and nitrogen dioxide (NO_2, annual mean 40 µg/m³) to protect human health. For Germany, the directive came into force by the 39th BImSchV [4] in 2010.

In densely populated urban areas, the air is polluted by a variety of pollution sources such as industry, domestic heating, road traffic, etc. The particulate matter concentrations, measured in NRW, are regularly below the EU limit values.

In 2020, NO_2 pollution in NRW fortunately dropped significantly. For the first time, all state measuring points complied with the limit values. Nevertheless, the safe compliance with the annual mean value for NO_2 (40 µg/m³) is still a challenge in metropolitan areas. For precautionary reasons, the pollution must be further reduced by suitable measures in order to ensure safe compliance with the limit values also in the future.

Diesel engines from inland vessels are a significant source of emissions along busy waterways. The quantity and effect of these emissions on air quality is influenced by factors such as traffic density, fleet composition, river morphology and location and equipment of berths.

The German inland navigation fleet has an average age of more than 50 years, and the propulsion engines used are on average older than 30 years. The emission regulations for ship propulsion are less strict than for trucks. More stringent new regulations only apply to new buildings of ships or in case an old engine is replaced by a new one (grandfathering). Therefore, significant reductions in emissions from inland navigation due to fleet renewals are not to be expected in the short term. Compared to advanced engine and exhaust technologies in road transport, there is a clear backlog demand in reducing exhaust emissions from the European inland navigation fleet (approx. 14.000 vessels).

In the discussion on suitable measures to reduce pollution, the NO_X emissions from inland vessels have therefore also come into the focus of public debate in recent years [5–9]. One of the arguments was, that inland vessels could be one of the main causes of the limit value exceedances for NO_2 occurring in urban areas.

The contributions of shipping have not yet been the focus of detailed official measurements. Within the framework of „CLINSH“, the opportunity arose to intensively investigate both the emission quantities and their immission-side contribution to the pollution situation of urban agglomerations with nitrogen oxides. For this purpose, measuring stations were set up on the German-Dutch border directly on the Rhine and special measuring programs on NO_2 pollution were carried out in the ports of Duisburg and Neuss/Düsseldorf from December 2017 to May 2019.

These special measurement programs had the following investigation objectives:

1. Investigation of the effect of emissions from shipping traffic on the Rhine on air quality on the left and right bank at Bimmen/Lobith.
2. Investigation of air quality in the major North Rhine-Westphalian inland ports of Neuss and Duisburg.

2. Measurement locations and methods

2.1 Measurement methods

2.1.1 Discontinuous measurements with passive samplers

In NRW, immission measurements of nitrogen dioxide (NO_2) are carried out both with the reference method specified by the EU Directive 2008/50/EC „on ambient air quality and cleaner air for Europe" [10] (see chapter 2.1.2) and with the so-called passive sampler method according to DIN EN 16339 „Air quality method for determining the concentration of nitrogen dioxide using passive samplers" [11; 12].

With this method, at each measurement site, two passive samplers (tubes) are placed in a weatherproof box, hanging from existing poles (e.g. lampposts), and are replaced after approx. 4 weeks of exposure time. For logistical reasons, the samples cannot always be changed on a monthly basis. For this reason, the annual mean value is combined into a weighted annual mean in proportion to the respective sampling period of the 12 individual results.

2.1.2 Continuous measuring stations

In addition to the passive samplers, the LANUV had the opportunity to install a continuous measuring station in the port area of Neuss as well as in the port area of Duisburg, which made high-resolution measurements of NO and NO_2 and also the collection of particulate matter and data on meteorology possible. The air is sucked in at a height of 3.5 m above the ground and conducted via pipelines to the measuring stations in the station. The data acquisition of the nitrogen oxides (NO_X) measurements takes place every five seconds. Extensive information on the LANUV measuring stations can be found on the LANUV homepage [13].

2.2 Measurement locations for the project

2.2.1 Measurement sites on the banks of the Rhine

In the area of the German-Dutch border (Bimmen/Lobith), the LANUV and RIJKSWATERSTAAT operate a continuous water monitoring laboratory (IMBL = International Monitoring Station Bimmen-Lobith). For CLINSH we use the opportunity to install passive samplers for NO_2 directly on the water sampling rafts (for water samples) on the left (Rhine-km 865; Bi_raft) and right (km 863.3; Lob_raft) bank of the Rhine (without influence of road traffic). For comparison, also measuring points on the dike (Bi_lab; Lob_dyke) were set up on both river sides (Fig. 1). The investigations have been running since 2016 and will be continued.

2.2.2 Measurement locations and measurement periods in the port areas

2.2.2.1 Port area of Duisburg

In the port area of Duisburg, a total of 27 measuring stations with passive samplers and one continuous measuring station (DURH) were set up. In addition, two road traffic measuring stations (DUFW, DUMB) of the state measuring network were included in the evaluation, which are located in the research area of approx. 6*5 km. The location of the measuring stations is shown in Fig. 2. The measurements of the continuous station will also be continued in 2021.

The measuring station „Duisburg Rheinhafen" (DURH, Rhine-km 782) is located on the Rhine dike below the harbour and is approx. 150 m from the lee-side right bank. It is therefore particularly suitable for investigating emissions from ships sailing on the Rhine.

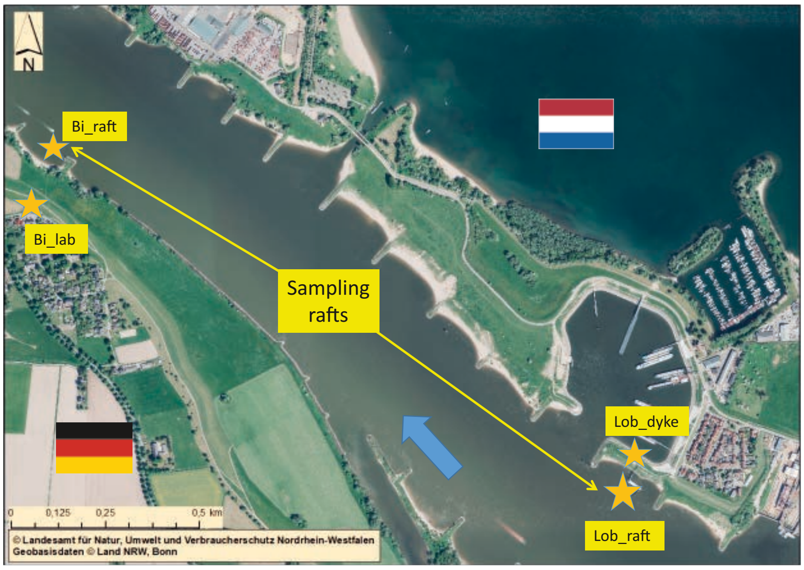

Fig. 1: Measuring sites on the German-Dutch border

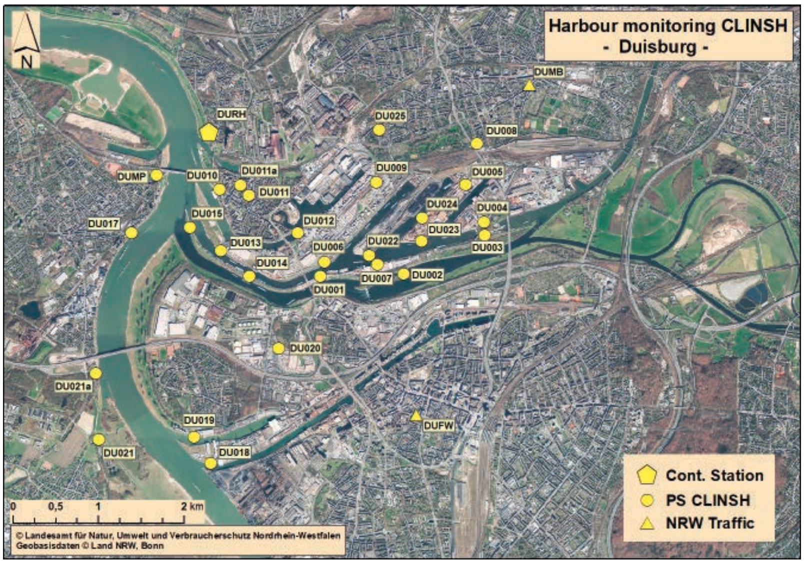

Fig. 2: Location of the monitoring sites in the port area of Duisburg
Cont. Station: Continuous measuring station | PS CLINSH: passive sampler CLINSH project
NRW Traffic: passive sampler of the State measurement network "road traffic"

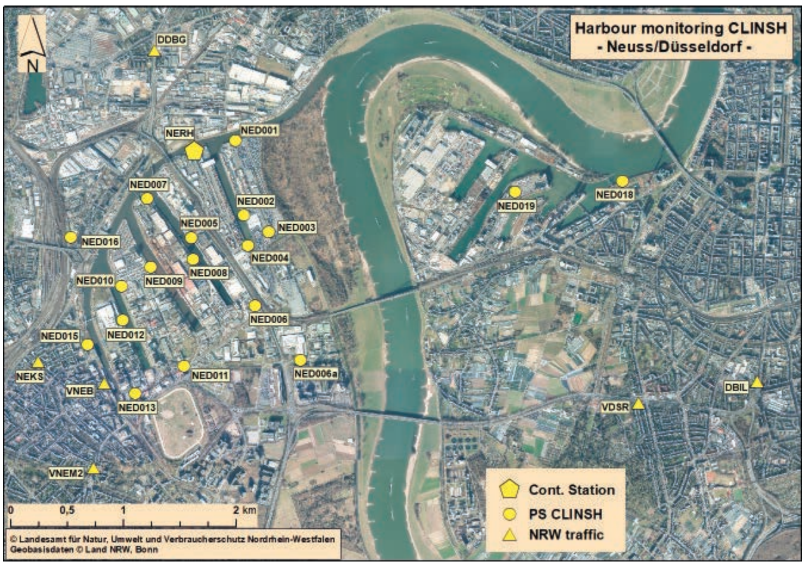

Fig. 3: Location of measuring points in the port area of Neuss/Düsseldorf
Cont. Station: Continuous measuring station | PS CLINSH: passive sampler CLINSH project
NRW Traffic: passive sampler of the State measurement network "road traffic"

Main wind direction West wind >>	NO_2 concentrations (µg/m³) annual mean			
	Left bank (windward)		Right bank (leeward)	
Year	Bi_lab	Bi_raft	Lob_raft	Lob_dyke
2017	18,0	19,8	21,0	–
Δ to Bi -lab		1,8	3,0	
2018	17,5	19,4	21,1	–
Δ to Bi -lab		1,9	3,6	
2019	15,8	16,8	20,6	20,1
Δ to Bi -lab		1,0	4,8	4,3
2020	13,5	14,1	18,1	17,8
Δ to Bi -lab		0,6	4,6	4,3

Tab. 1: Annual mean values of NO_2 air pollution from the measuring points at the German-Dutch border near Bimmen/Lobith

2.2.2.2 Neuss/Düsseldorf port area

In the port area of Neuss/Düsseldorf, a total of 19 measuring stations with passive collectors as well as one continuous measuring station (NERH) were installed. The location of the measuring points is shown in Fig. 3. In addition, six traffic measuring stations (NEKS, VNEB, VNEM2, VDSR, DBIL, DDBG) of the official NRW measuring network are located in the research area (approx. 8*5 km), the results of which are also considered in the evaluation.

The measuring station „Neuss Rheinhafen" (NERH) is located on the premises of the company UCT (Transshipment Container Terminal) in the Neuss harbour area directly at the quay wall of the ship berth and is therefore particularly suitable for investigating the emissions of ships operating in the harbour.

3. Results

3.1 Air quality on the Rhine

The measuring stations installed in the area of the German-Dutch border (Bimmen/Lobith) enable a direct assessment of the effect of ship exhaust gases on air quality. The measurement results of the Bi_lab measuring station on the windward side of the laboratory building were chosen as the reference value. This measuring point is located about 150 m from the bank of the Rhine.

The measuring points, located on the sampling rafts on the left bank of the Rhine (Bi_raft) and on the right bank of the Rhine (Lob_raft), are directly influenced by the ship exhaust gases, wherefore other locally directly acting emission sources (e.g. road traffic) can be excluded. With the additional measuring point installed in 2018 (Lob_dyke), the lee-side height distribution of the immissions can also be better assessed.

The annual mean values to be used for assessing the air quality could be formed for the data sets from 2017 to 2020 (Tab. 1)

Furthest from the Rhine on the dike (150 m) at the laboratory building (Bi_lab) on the left bank of the Rhine (windward side), the annual mean NO_2 value was 17 to 18 µg/m³ in 2017 and 2018. In 2019, the value dropped to about 16 µg/m³ and in 2020 further to 13.5 µg/m³. The results at this measuring point roughly correspond to the so-called „regional background pollution" locally present in the area of Bimmen (caused by all emission sources present at the Lower Rhine and the long-distance transport of the input of distant major sources). At the Lower Rhine, this „regional background" already includes a share of barge emissions in the order of 1–2 µg/m³.

On the sampling rafts, the weighted annual mean NO_2 concentrations on the left bank (windward side) were 19.8 µg/m³, respectively 19.4 µg/m³ in 2017 and 2018. Compared to the concentrations at the top of the dyke (Bi_Lab), the concentration here was about +2 µg/m³ higher in both years. It can be assumed, that this increase was solely caused by shipping. In 2019 (16.8 µg/m³) and 2020 (14.1 µg/m³), the concentrations on the left-hand sampling raft decreased. Noticeable here is the progressively decreasing difference in the concentration increase caused by shipping. In 2019, the difference was only +1.0 µg/m³ and fell further to +0.6 µg/m³ in 2020 (Fig. 4).

At the German-Dutch border, the wind comes predominantly from westerly directions. For this reason, it is to be expected, that the ship exhaust gases mainly have an effect on the lee side on the right, eastern bank of the Rhine. The measurement results on the sampling raft (Lob_raft) from the right bank (Lobith-Tolkamer) confirm this thesis. In 2017 and 2018, the annual mean NO_2 value here was 21.1 µg/m³. The increases in concentration compared to the Bi_lab measuring point were in the range of +3 to +3.6 µg/m³. This difference is also attributable to emissions from passing inland waterway vessels. In 2019, the difference increased to +4.8 µg/m³ and was also +4.6 µg/m³ in 2020.

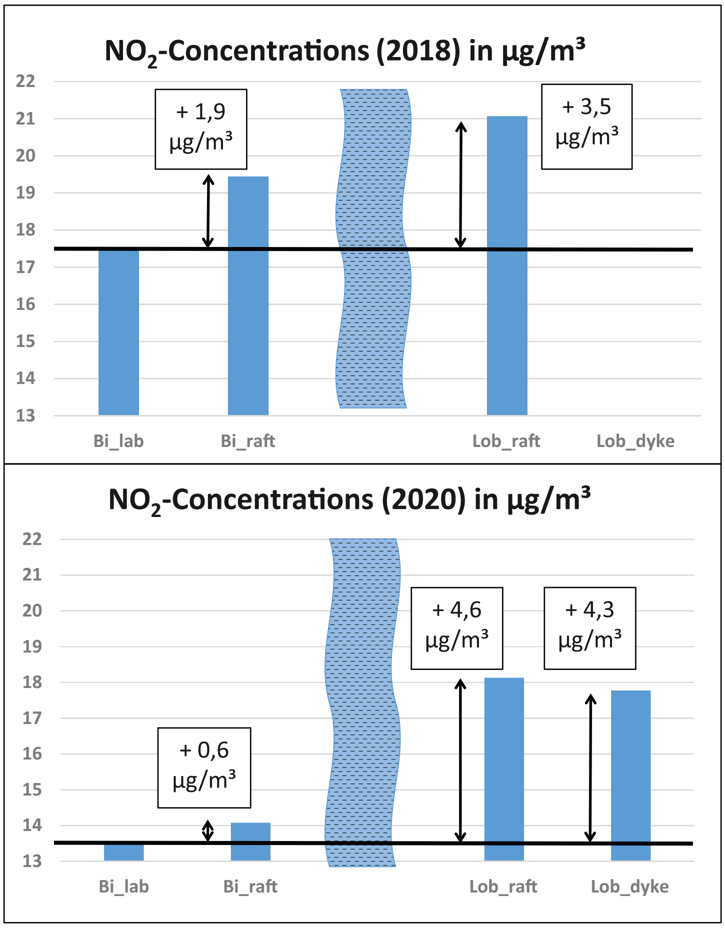

Fig. 4: Concentration increases of air pollution due to ship emissions from the Rhine at the German-Dutch border near Bimmen-Lobith

In 2019 (20.6 µg/m³) and 2020 (18.1 µg/m³), the annual mean values also decreased on the Lobith sampling raft, but not as significantly as on the left Bank. The differences between the concentrations measured here and the „regional background load" of Bi_lab, caused by the ships, show an opposite picture to the development of the ship influences on Bi_raft.

Measurements, carried out since 2019 on the dike crest on the right bank, show that ship emissions are still detectable at a similar height on the dike crest on the leeward side, despite a low discharge height above the water level.

3.2 Air quality in the ports

A second focus of the investigations concentrated on air quality pollution from ships and port operations in the ports of Neuss and Duisburg. In the ports of Duisburg and Neuss, very extensive and dense measurement networks (NO_2) were set up by the LANUV for „CLINSH".

On company premises or commercial areas without public access, the limit values for the protection of human health do not have to be complied with, but they serve here as a reference value for the classification of the results. Many of the measuring points in the port area are located in such areas.

Before evaluating the results, the so-called „background pollution", present everywhere in the conurbations along the Rhine, must be determined at first.

For modelling purposes in the context of clean air planning, the LANUV determines the magnitude of this background pollution from the mean value of six „background stations" not directly dominated by road traffic (Wesel, Hattingen, Datteln, Düsseldorf-Loerick, Cologne-Chorweiler and Hürth). This resulted in a background pollution for Duisburg and Neuss of about 21 µg/m³ NO_2 for the year 2018. Increases in concentration, exceeding the background load, are regarded as effects that can be assigned to regionally effective emission sources.

A modelling of the „Rheinisches Institut für Umweltforschung" (University of Cologne) with the EU-RAD model resulted in a lower value of 15.6 µg/m³ NO_2 [14] for the ubiquitous NO_2 pollution (background), present in the Duisburg metropolitan area in 2016.

The classified annual mean NO_2 values determined by CLINSH for the individual monitoring sites in 2018 are shown in Fig. 5 for Neuss and in Fig. 6 for Duisburg. For the measuring points in the port of Neuss, annual mean NO_2 values between 29 µg/m³ and 39 µg/m³ were recorded in 2018. For some of the measuring points in the Neuss port area with higher pollution levels in an internal comparison, it can be assumed that, in addition to the emissions caused by shipping and port operations, influences from vehicle emissions on busy (through) roads in the immediate vicinity are also effective. At four of the six traffic measuring points of the state measuring network located in the study area, significantly higher annual mean NO_2 concentration values were determined in 2018 than in the port area (VNEB 45 µg/m³; NEKS 44 µg/m³; DBIL 54 µg/m³; DDBG 43 µg/m³).

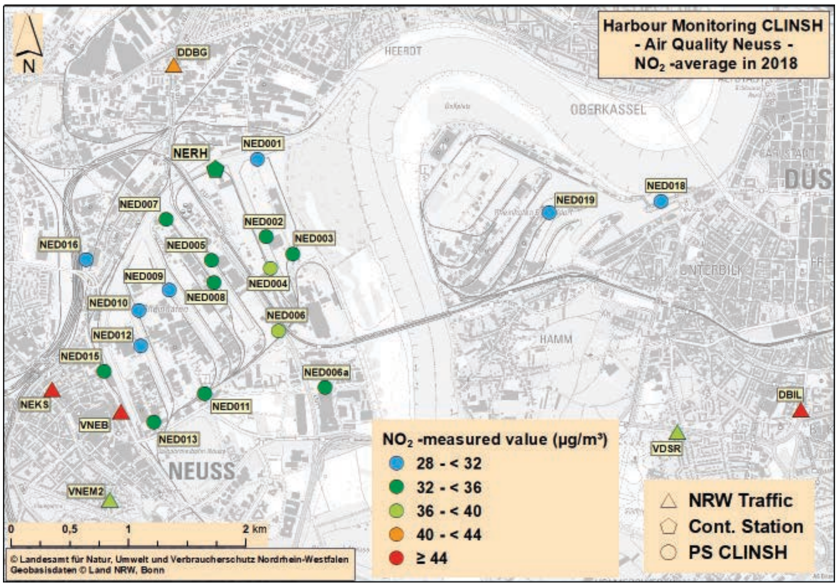

Fig. 5: Classified results of the annual mean values (2018) of the measured NO_2 concentrations in the port area of Neuss

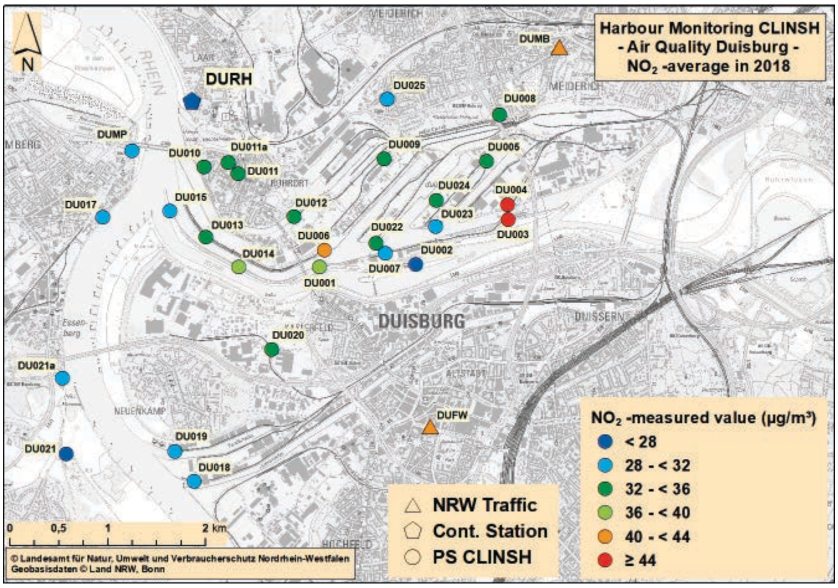

Fig. 6: Classified results of the annual mean values (2018) of the measured NO_2 concentrations in the port area of Duisburg

At the monitoring sites located directly on the Rhine in the Duisburg area, annual mean NO_2 values of 26 µg/m³ to 30 µg/m³ were measured on the windward side at the left bank and 27 µg/m³ to 32 µg/m³ on the leeward side at the right bank (Fig. 6). Compared to the background pollution, site-specific increases in the range of 5 µg/m³ to 11 µg/m³ NO_2 were recorded for the measuring sites located directly on the Rhine in Duisburg in 2018. However, the concentration increases, that can be detected here, are not only attributable to the influence of ship exhaust gases. The air quality at these sites is also influenced by other urban (road traffic, domestic heating, etc.) and industrial emission sources.

In the area between the harbour basins and at the harbour canal, the NO_2 concentrations at 11 measuring points are between 31 and 37 µg/m³. The twelfth measuring point (Du006) at the harbour canal shows a higher load of 43 µg/m³, which could also have been caused by construction work in the vicinity of the measuring point. The EU Di-

Station	Year	NO_2 Annual average µg/m³	PM_{10} Annual average µg/m³	PM_{10} Daily mean with exceedances of 50 µg/m³
DURH	2018	27	23	10
	2019	26	19	2
	2020	21	22	1
NERH	2018	33	22	6
	2019	30	19	3

Tab. 2: Annual mean values for NO_2 and PM_{10} at the two continuous monitoring stations in Neuss and Duisburg.

rective is not applicable here, as access was only possible via a construction site/industrial wasteland.

The measuring points Du020 and Du025, located on industrial sites, showed a concentration of 30 to 32 µg/m³ NO_2. For the three measuring points located in the residential area „Ruhrort" between the port and the Rhine (Du010; Du01; Du011a), NO_2 concentrations between 33 and 36 µg/m³ were found, here the EU limit value is safely complied with.

Also in Duisburg the traffic measuring points of the state measuring network (DUFW 41 µg/m³; DUMB 42 µg/m³) generally showed higher NO_2 concentrations than in the port areas.

In order to be able to assess the influence of the locking activities at the two locks, passive samplers were installed on the Meiderich lock premises to the right and left of the lock chamber (Du0003; Du 0004). On both collectors, the annual mean NO_2 concentrations in 2018 were 47 µg/m³. The values can be explained by the locking operations (with the ships' main engines running), in which the ship exhaust gases already collect in the lock chamber during the valley lock and are then pressed out of the lock chamber in concentrated form by the rising water during the subsequent upstream lock. The EU Directive does not apply to the lock area.

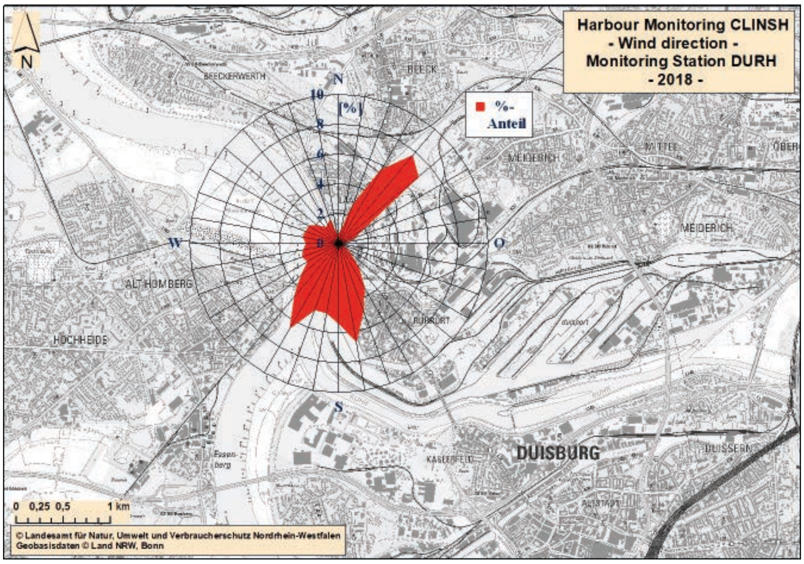

Fig. 7: Percentage distribution frequency of wind directions in 2018

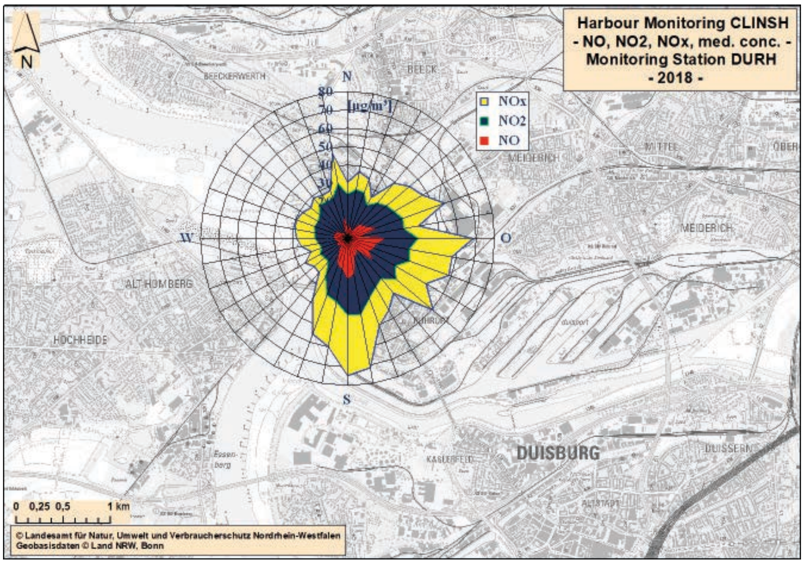

Fig. 8: Mean values of the concentrations of nitrogen oxides (NO, NO_2) occurring at the respective wind directions in 2018

3.3 Results of the continuous measurements of the stations in Duisburg (DURH) and Neuss (NERH)

3.3.1 General pollution situation

At both measuring stations (DURH; NERH) a similar decreasing development of concentrations as already described for the NO_2 concentrations at the German-Dutch border was observed for the annual parameters for NO_2 as well as for PM_{10} over the years. At both measuring stations, which are directly influenced by shipping and port operations, the annual mean values are clearly below the limit values of the EU Directive (Tab. 2).

On the one hand, the continuous measurements make it possible to better assess the temporal concentration trends of the investigated pollutants and on the other hand to relate them to the respective meteorology. The prevailing wind directions at certain concentration levels play an important role in clarifying the causes of pollution.

Fig. 7 shows the percentage distribution of wind directions at the DURH monitoring station during the year under investigation. In 2018, southwesterly and southeasterly wind directions had the largest share in the distribution. Particularly in wind directions with westerly components, sweeping the Rhine, ship emissions are carried in the direction of the measuring station. For northeasterly wind directions, which also have a larger share in the distribution, no ship emissions are to be expected at the station. Noteworthy is the small share of easterly wind directions (90°) in the distribution.

Figs. 8 and 9 show the mean values of the NO_X and PM_{10} concentrations occurring in the respective wind directions. The diagrams thus show the spatial distribution of the concentration occurrence. It is clearly visible in Fig. 8 that rather low NO_X concentrations were measured with westerly wind directions, which sweep the Rhine and thus include ship emissions. The highest concentrations occur with southern (180°) and eastern wind directions (90°). Especially the very rarely occurring easterly wind directions contain higher NO_X concentrations, which are not likely to originate from the ships, but from other sources in the industrial and urban area.

Fig. 9 shows a similar distribution pattern for PM_{10}. Here, too, increased PM_{10} concentrations occur with easterly wind directions compared to westerly winds, which are likely to originate from the industrial and urban area.

3.3.2 Recording of the emission occurrence by inland shipping

Nitrogen oxide emissions from diesel engines consist of a mixture of nitrogen monoxide (NO) and nitrogen dioxide (NO_2). The sum of both substances is called NO_X. Directly at the exhaust, the proportion of NO initially predominates. A part of it is converted into NO_2 by the air chemistry within a short time after discharge.

With the continuous measuring station in Duisburg, the rapid succession of measurements made it possible to directly record the pollution peaks of passing ships in westerly wind directions sweeping the Rhine (Fig. 10).

With the help of the AIS signals (Automatic Identification System, mandatory automatic identification system for commercial ships) emitted by the ships, these peaks can in many cases be assigned to the size class, direction of travel and speed of the passing ship. Reliable identification is always possible, when individual ship peaks can be distinguished from each other. If several ships pass the station at the same time, the peaks overlap. A clear assignment of the peak to a ship is not possible then.

The measurements of the continuous measuring station in the Duisburg area (DURH) also show a clear NO_X peak in the immission measurements for each passing ship when the wind direction (westerly) is suitable (Fig. 11). The graph shows the course of the measured wind direction (blue) and the NO_X concentrations over time. From 04:00 p.m. to about 09:45 p.m. the wind came from the north-west of the Rhine. The emission peaks of the passing ships are clearly visible. From about 09:45 p.m., a situation with circulating winds prevailed, ship peaks are no longer identifiable.

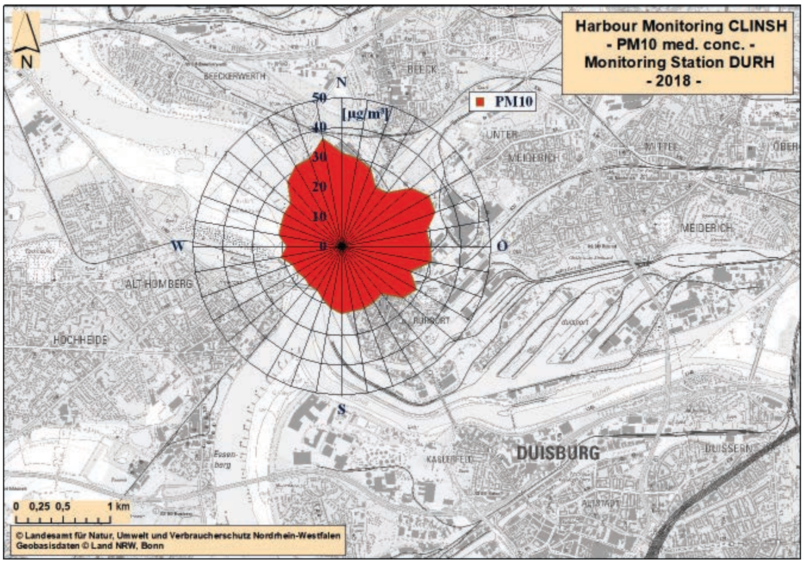

Fig. 9: Mean values of the concentrations of particulate matter (PM_{10}) occurring in the respective wind directions in 2018

Fig. 12 shows a situation with an initial southeasterly to southerly wind direction. The course of the red concentration line shows a relatively high and rather indifferent NO_X load. The concentration course shows that the higher nitrogen oxide concentrations visible in Fig. 8 do not predominantly originate from ships, but from other sources. Around 07:00 a.m., the wind shifts to a southwesterly direction over the south and sweeps across the Rhine. The indifferent load drops significantly to about one third of the previous concentrations, at the same time the peaks of the ships, passing on the Rhine, become visible.

4. Discussion

4.1 Effect of ship emissions directly on the bank

In general, there was a decreasing trend in the absolute detectable concentration levels in Bimmen/Lobith for all monitoring sites in the years 2017–2020. However, the de-

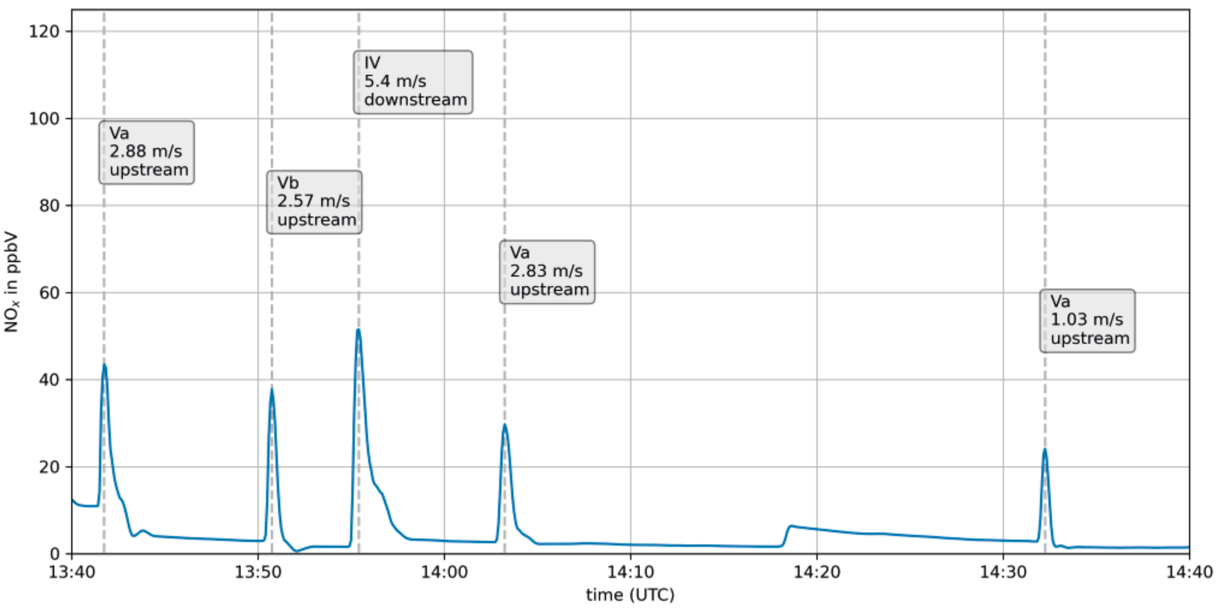

Fig. 10: Assignment of NO_X peaks to the direction of travel, speed and length classes of the passing vessels by means of AIS signals
VI: Europe vessel (Rhine-Herne Canal vessel): 85 × 9.50 × 2.5 m, cargo capacity 1.350 t
Va: Large Rhine vessel: 100 × 11.4 × 3.5 m, cargo capacity 2.800 t | Vb: Large Rhine vessel: 135 × 11,4 × 3,5 m. cargo capacity 4.000 t

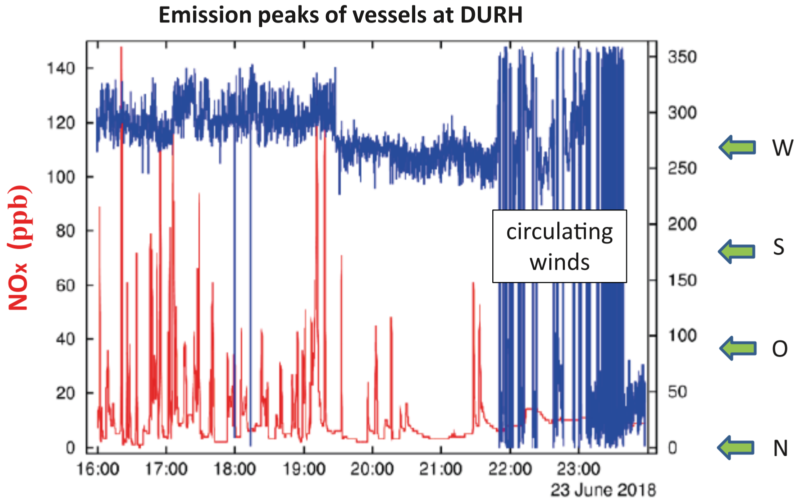

Fig. 11: Continuous measurement of nitrogen oxide (NO_x) emissions from passing ships in case of south-westerly wind direction at DURH

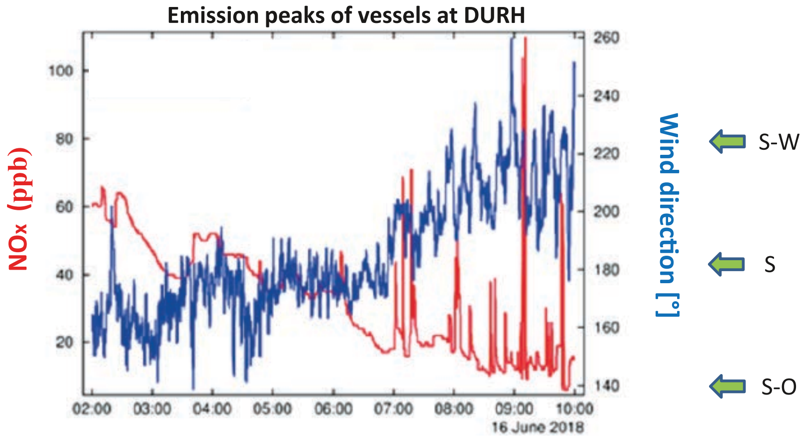

Fig. 12: Effects of changing wind directions on the nitrogen oxide (NO_x) concentrations measurable at the DURH station. High indifferent load with wind from SE and S. Low basic load with ship peaks with wind from SW crossing the Rhine

velopment of the concentration increases, caused by the inland vessels on the sampling rafts (Bi_raft, Lob_raft), was different.

Based on the measurements, carried out on the Rhine in Bimmen/Lobith, the effect of ship emissions (about 110.000 ship passages per year) can be estimated quite well. The shipping channel in the investigated area is rather on the left side of the Rhine. When the water level is sufficient, however, it can be observed that ships, travelling upstream, also use the right side of the Rhine.

The emissions are mainly carried by the wind on the leeward side (eastern, right bank) and are effective there. The windward measurement result at the IMBL laboratory building was chosen as the reference value („regional background"). The annual mean NO_2 values, measured here, were 18 µg/m³ in 2017 and fell to 13.5 µg/m³ by 2020. These values correspond quite well in their magnitude with the EURAD modelling result of the University of Cologne for the background pollution in Duisburg (15.6 µg/m³) in 2016 [14].

In comparison with the „regional background pollution" on the left bank, shipping traffic on the right bank leads to significant increases in concentrations. In 2017/18, these were at an annual average of +3 to +3.5 µg/m³ and increased to about +4.5 to +5 µg/m³ NO_2 in 2019/2020.

Also on the sampling raft on the left bank, shipping traffic leads to concentration increases, but these are more moderate. In 2017 and 2018, its annual average was about +2 µg/m³ and decreased in the following years (2019: 1 µg/m³) to +0.6 µg/m³ in 2020.

The differences between the concentrations measured at Lob_raft and the „regional background load" of Bi_lab, caused by the ships, show an opposite development of the ship influences on Bi_raft.

In 2019, the difference increased to +4.8 µg/m³ and was +4.6 µg/m³ in 2020. The dissimilar development of the differences could have two causes:

a. Shift of upstream shipping traffic to the right side of the river, possibly caused by low water levels on the left side of the Rhine combined with decreasing flow velocities on the right side.
b. Stronger share of westerly wind directions in 2019 and 2020.

In 2019 and 2020, a supplementary NO_2 measurement was carried out on the leeward dike crest. It shows that the emissions produced just above the water level are also detectable at a height of 8 to 10 m above the water level and can have an effect beyond the dike crest in the hinterland. Thus, concentration increases due to ship emissions can also occur in the lee-side near-shore parts of the agglomerations. However, it must be taken into account that these effects decrease with increasing distance from the banks of the Rhine. Such experiences are also made with the inner-city effects of emissions from road traffic.

Even with reduced traffic density, the effects of inland navigation emissions decrease. The following picture emerged for 2018: The location of most ship passages for NRW is on the German-Dutch border in the Bimmen-Lobith area (Rhine km 865). Taking the number of ships passing here as a reference (100 %), the number of ships is still about 70 % at Duisburg (km 782), about 57 % below Neuss (km 744) and about 45 % shortly before the border with Rhineland-Palatinate (Bad Honnef, km 640). Thus, it is to be expected that upstream, due to the lower number of moving ships, the ship-related shares of air pollution in the cities along the Rhine will also decrease.

4.2 Pollution situation in the port areas

The measurement results show that the NO_2 concentrations, detectable directly on the Rhine and also in the port areas, were lower than expected. At the special measuring points in the port area of Neuss, all annual mean values were below 40 µg/m³.

The situation was similar in the port area of Duisburg. Also here, almost all NO_2 annual means were below 40 µg/m³ in 2018. Only three measuring points in Duisburg showed values above 40 µg/m³. These measuring points were located in areas not accessible to the public, so that the EU Directive does not apply here. For the Meiderich lock, the high values could be explained by the concentrated ship exhaust gases, escaping from the lock chamber. The third measuring point was probably influenced by construction activities.

The measurement results in the ports of Neuss and Duisburg show that the contribution to urban air pollution caused by shipping traffic cannot be of the magnitude previously assumed in public discussions. Almost all measuring points in the port areas and also in residential areas directly on the Rhine show annual mean NO_2 concentrations well below 40 µg/m³.

In contrast, six of the eight „traffic stations" of the state measuring network also located in the study area on busy roads showed NO_2 concentrations between 41 and 54 µg/m³ for the annual mean in 2018. The statistical comparison of NO_2 concentration levels and trends of the monitoring stations set up for CLINSH with the traffic monitoring stations shows significant differences both in Neuss and in Duisburg. The courses of the traffic stations are significantly above the mean course of the CLINSH stations. This clearly shows the concentration-increasing effect of street vehicle emissions.

4.3 Outlook

In cooperation with the University of Bremen, it was possible to determine the ship size, direction of travel and speed of more than 10.000 ship passages as well as the corresponding emission factor of each ship based on the continuous measuring of the DURH station. These emission factors and the other data, obtained within the framework of CLINSH, form an important basis for a more realistic recording of the actual effects of ship emissions and thus also for the future updating of the emission register „shipping traffic" of NRW [15].

The final evaluations (e.g. detailed analyses of the load shares of various emission sources for the individual measuring points) and detailed reports on the EU Life project „CLINSH" will not be available until the end of 2021.

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