الجمهورية اللبنانية
وزارة البيئة

الوزير

بيروت، في ٦ ـ ١٢ ـ ٢٠١٩

تعميم رقم ١٩/ ...

متعلق بدليل تنقيح وتدقيق بيانات الشبكة الوطنية لرصد نوعية الهواء المحيط

استناداً إلى القوانين والأنظمة المرعية الإجراء لا سيما قانون حماية نوعية الهواء رقم ٧٨ تاريخ ٢٠١٨/٤/١٣ سيما البند ٧-١ من المادة ٧ (التقرير الوطني لنوعية الهواء المحيط) الذي ينص على ما يلي: "تضع وزارة البيئة، بشكل دوري (شهريا على الأقل)، تقريراً وطنياً عن نوعية الهواء المحيط يكون مرجعاً رئيسياً للمعلومات المتعلقة بنوعية الهواء المحيط ومصادر تلوّثه"؛

وحيث أن وزارة البيئة تملك شبكة وطنية لرصد نوعية الهواء المحيط مؤلفة من:

- ١٥ محطة لرصد الملوثات الهوائية المعيارية
- ٣ محطات لرصد الغبار
- ٨ محطات للرصد الجوي؛

وحيث أن البيانات الناتجة عن شبكة الرصد، التي تشكل المحتوى الأساسي للتقرير الوطني لنوعية الهواء المحيط تستلزم قبل نشرها جملة من عمليات التنقيح والتدقيق للتأكد من صحة هذه البيانات وضمان جودتها وسلامتها مما يضمن تجنب أية قراءات وتحليلات خاطئة للوضع البيئي تؤدي إلى استنتاجات خاطئة؛

ونظراً لتعدّد منهجيات عملية التنقيح والتدقيق؛

أعدّت وزارة البيئة دليلاً موحّداً لتنقيح وتدقيق البيانات الناتجة عن الشبكة الوطنية لرصد نوعية الهواء المحيط (Validation Guideline) ليكون هذا الدليل المرجع الرسمي في لبنان المعتمد من قبل الوزارة لإجراء تدقيق وتنقيح البيانات الناتجة عن الشبكة الوطنية لرصد نوعية الهواء المحيط.

وزير البيئة
فادي جريصاتي

مرفق ربطاً:
دليل تنقيح وتدقيق البيانات الناتجة عن الشبكة الوطنية لرصد نوعية الهواء المحيط

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VALIDATION OF AMBIENT AIR QUALITY MONITORING DATA

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1 Objectives of data validation

Data validation is a key procedure of quality assurance. It ensures that the data will properly serve the purpose for which they were collected for; it can identify whether air pollutant concentrations are within the Lebanese standards that are used to protect public and environmental health. Data validation shall ensure avoiding "erroneous" analyses of the state of the environment and hence drawing wrong conclusions. Moreover, data validation shall provide sound data for modeling.

Data processing in the station by the data logger, the criteria for calculating valid 1-hour-mean values, and the information transmitted from the station to the central data-base are documented in Appendix A.
Also, the station maintenance performed by the station operation staff (maintenance team) on a periodic basis provides important input for the data validation process (see Appendix B).

At the Ministry of Environment, data validation of 1-hour-mean values (1-hr MV) performed by air quality experts comprises 3 steps:

1. Daily data validation of raw data transmitted from the monitoring station to the database;
2. Monthly data validation after information from the periodic station maintenance is available, which can be performed every fortnight or monthly, preceding the publication of the monthly report.
3. Final data validation – and, if necessary, data correction – based on the results of the quarterly calibration, preceding the publication of the annual report.

The objectives of the daily data validation are:

- Removing erroneous values originating from the malfunction of the monitoring equipment.
- Identifying technical problems at the monitoring station and taking necessary steps by contacting the maintenance team.
- For preparing data for publication e.g. in a daily air quality report or an alert, validation is useful in order to avoid the dissemination of likely erroneous values.

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The objectives of the monthly data validation are:

- Clarifying questions concerning "doubtful" data that have been observed during the daily data validation, based on information from the station maintenance staff.
- Removing erroneous values originating from malfunctions of the monitor or other technical problems at the station.

The objectives of the final data validation are:

- Corrections of a zero or span drift, if a drift has been identified by the quarterly calibration exceeding a specified range.
- Removing erroneous values, based on information about technical problems at the monitoring station which has not been available at previous data validation steps.

Any data validation is applied to the raw data transmitted from the monitoring station, i.e. 1-hour-mean values. For each level, a set of criteria will be considered to validate the data.

2 Regulatory requirements in Lebanon

The Law on Air Quality Protection (Law 78/2018) in Lebanon states that an annual report on air quality in Lebanon shall be published. Moreover, in line with the National Strategy for Air Quality Management in Lebanon, the Air Quality Department at the Ministry of Environment publishes monthly reports on air quality throughout the Lebanese territory based on the data collected from the National Air Quality Monitoring Network.

3 Daily data validation

Daily data validation has to be done by an expert familiar with the pollution situation at the monitoring stations. It can be supported by software for automated data validation which identifies likely erroneous values and finalized by human intervention.

It is strongly recommended not to discard "suspicious" values automatically without any manual check. Such procedure could cause the erroneous loss of values only due to the inadequate configuration of the validation software.

3.1 Criteria for the daily data validation

The daily data validation shall – irrespective if supported by an automated data checking software – consider the criteria given in Table 1.

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Table 1: Criteria for daily data validation and actions to be taken.

Problem	Information and criteria	Action on data	Action to be taken by the monitoring network operator
A. No data			
No data transmitted from the station			Check electric power supply; Send technician to the monitoring station to check technical problems.
			Check all software and hardware components for data transmission. Contact IT staff of monitoring network operator. Send technician to the monitoring station to check technical problems.
No data from single monitoring devices	Status information from the monitoring device.		Send technician to the monitoring station to check technical problems or change monitoring device.
B. Check of air conditioning			
Check if monitoring site indoor temperature	Monitoring site indoor temperature is outside the range specified in the type approval test of the monitoring device (20 – 30 °C)	Flag data "invalid"	Send technician to the monitoring station in order to repair air conditioning equipment
C. Automatic zero/span checks			
Automatic span check	Automatic Span check: Deviation exceeding 5 %		Send technician to the monitoring station for calibration
Automatic zero check	Automatic zero check: Deviation exceeding the criteria listed in Table 2.		Send technician to the monitoring station for calibration
D. Checks of plausibility of measurement data			
Identical values over several hours	Status information from the monitoring device.	Flag data "invalid" if malfunction of monitoring device is obvious.	Send technician to the monitoring station to check technical problems or change monitoring device.
Values distinctly out of expected range (incl. single or irregularly negative values)	Status information from the monitoring device.	Flag data "invalid" if malfunction of monitoring device is obvious.	Send technician to the monitoring station to check technical problems or change monitoring device.
	Status information from the monitoring device indicates that the outlier is influenced by zero or span gas	Flag "invalid" in case of an outlier caused by automatic Internal Zero-Span check.	Modify time frame for zero/span check.

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Problem	Information and criteria	Action on data	Action to be taken by the monitoring network operator
	Check if suspicious values may result from station maintenance or calibration without switching off-line ("manual").	Flag "invalid" in case of manual zero/span check or manual calibration.	
	Check if there is information about unusual emissions near the monitoring site, e.g. from construction activities, dust storms, outdoor waste burning, wildfires, etc.	Make notes that further validation based on additional information is necessary.	Ask technician to investigate unusual emissions near the monitoring site.
More or less constantly negative values over several days or weeks	Automatic zero check: Indicates if negative values originate from a negative zero drift.		If the automatic zero deviation exceeds the values listed in Table 2, calibration is necessary.

Constantly negative values over several days or weeks may be caused by a zero drift. If the automatic zero deviation exceeds the values listed in Table 2, calibration is necessary. Negative values greater than the criteria presented in Table 2 have to be kept "valid" in the database and will have to be corrected according to the results of the calibration (see chapter 5).

Table 2: Action criteria for zero drift

SO_2	NO, NO_x	CO	O_3
≤ -4 ppb or ≥ 4 ppb	≤ -4 ppb or ≥ 4 ppb	≤ -0,5 ppm or ≥ 0,5 ppm	≤ -4 ppb or ≥ 4 ppb

Before conducting the final data correction discussed in chapter 5 (i.e. before publishing the annual report), handling of **preliminary data** below 0 is as follows:

1. Values between the negative detection limit (Detection limits are given in Table 3) and 0:
   - published as "below detection limit" or "not detectable".
   - the numeric value of these data shall be used for data aggregation (e.g. calculation of daily mean values or monthly mean values).
2. Values below the negative detection limit:
   - published as "missing"
   - not used for data aggregation

Aggregated data (e.g. daily mean values or monthly mean values) which are between 0 and the negative detection limit shall be published as "below detection limit".

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Table 3: Detection limits of the instruments installed in the air quality network

Pollutant	$NO/NO_2/NO_x$	SO_2	CO	O_3	PM_{10}, $PM_{2.5}$
Network Phase I	0.4 ppb	1.0 ppb	50 ppb	0.4 ppb	0.5 µg/m³
Network Phase II	0.4 ppb	0.4 ppb	50 ppb	0.6 ppb	1.0 µgm³

Note: Detection limit for PM_{10} and $PM_{2,5}$ refer to 24-hour mean values.

Note: Besides the monitoring devices' status information and the automated data check, the investigation of (possibly) erroneous values need experience on what is to be "expected" at a specific monitoring site.

3.2 Numeric criteria for automatic data checks

A software for data checking may support the daily data validation.
The software can automatically check:

1. Transmission of data
2. Daily zero and span checks – does the deviation exceed the thresholds for action?
3. Indications of technical problems (e.g. outlier checks)

The expert responsible for data validation shall be informed automatically about any detected problems, and shall take action according to Table 1.

The data checking software should provide the information listed in Table 4 to the expert responsible for data validation.

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Table 4: Output and configuration of the data checking software.

To be checked – for each pollutant at each station	Output	Alert for taking action	Comments
Data transmission from the monitoring station	Time of latest 1-hour mean value	Time lag > 3 hours	Time lag should be set corresponding to the performance of the data transmission.
	Number of valid 1-hour-mean values within the latest 24 hours	Number of valid 1-hour mean values within the latest 24 hours < 23 [1]	Alternatively to checking the latest 24 hours, any other reasonable time period (e.g. the latest calendar day, or 12 hours or 48 hours) could be configured. The alert threshold shall correspond to the planned data loss due to the daily zero/span checks.
Daily zero and span check	Numeric value of zero and span deviation	Zero exceeds the values given in Table 2; Span deviation exceeds 5 %.	
Indications of technical problems	Check for Outliers	1-hour-mean value exceeds a specified value	The outlier threshold has to be selected for each pollutant and station corresponding to the pollution level to be expected at each station.
	Check for "constant" values	3 identical consecutive 1-hour-mean values	"identical" corresponding to the numerical accuracy of the station data-logger.
	Check NO, NO_2, NO_x	$NO + NO_2 \neq NO_x$ $NO > NO_x$ $NO_2 > NO_x$	"equal" corresponding to the numerical accuracy of the station data-logger.
	Check PM fractions	$PM_{10} < PM_{2.5} < PM_1$	

Note: The thresholds for automated outlier checks per pollutant should be set specifically for each station corresponding to the pollution level observed.
Uniform thresholds at high concentrations would pose the risk of ignoring implausible values at rural background sites; low thresholds could cause inadequately frequent "outlier alert" at traffic or industrial sites.
Therefore, setting outlier thresholds is a step-wise process that requires some experience observing the pollution levels at each station for several years.

[1] Assuming 1 hour loss due to ISZ

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The assessment of "suspicious" data – either flagging as "not valid" or keeping valid – must be documented.

Reasons for flagging as "not valid": Technical problems related to the instrument or the shelter

Reasons for "unusual" values, which are caused by real emissions and have to be kept "valid" include: Agricultural tilling, African dust, Asian dust, industrial accidents, cleanup after a major disaster, construction/demolition works, fireworks, forest fire, high pollen count, erosion of natural or agricultural surfaces by strong winds, infrequent large gatherings, outdoor waste burning, fire, rerouting of traffic, , terrorist act, unusual traffic situations, etc.)

3.3 Meteorological data

The validation of meteorological data covers both quantitative criteria and a plausibility check.

Table 5: Quantitative criteria for the check of meteorological data

Parameter	Values to be discarded	Values that need further investigation
Wind speed	< 0 m/s	Upper limit to be specified depending on location of the monitoring site
Wind direction	< 0 °, > 360 °	
Temperature		Range to be specified depending on location of the monitoring site
Relative Humidity	< 0 %, > 100 %	Constant values below 95 % over several hours.
Precipitation	< 0 mm	Upper limit to be specified depending on location of the monitoring site
Air pressure		Range to be specified depending on altitude of the monitoring site. At sea level, values < 960 hPa and > 1080 hPa should be investigated.
Global Radiation	< 0 W/m² > 0 W/m² during night-time	> 1400 W/m²

Constant values over several hours indicate electronic malfunction of the monitoring equipment. Such problems require sending the technician to the monitoring station to check technical problems or to change the monitoring device.
Exception: Relative humidity can be constant at 100 % (or some percent less, if saturation is set to some % below 100 % on an electronic level) during rainy or foggy weather.

The quantitative checks according to Table 5 can be performed by software.

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In any case, the manual validation of meteorological data should include the following qualitative criteria:

- Typical annual and diurnal variation of temperature and relative humidity.
- Temperature and relative humidity are usually anti-correlated.
- Typical diurnal variation of wind direction and wind speed in areas with regular sea-breeze, valley wind or slope wind circulation.
- Additional impact of the local topographic situation and street configuration on the wind direction.
- Impact of the topographic situation on the spatial distribution of precipitation.

3.4 Criteria for manual data validation

The expert responsible for data validation often reviews the tabular data by graphing it or by looking at the graphs, especially when the data is suspect since it is easier to see trends and relationship patterns.

Meteorological data

Wind direction indicates advection from specific sources.
High PM_{10} levels may be caused by dust suspension by strong wind.
High ozone levels correspond with hot, sunny weather. Cloudy weather or rain usually correspond to low ozone concentrations.
Temperature inversions often correspond to high concentrations of NO, NO_x, SO_2, CO, and PM near low sources.

Comparison of different pollutants at the same site

The temporal variation of pollutants originating from the same sources is to be expected to be similar:

- NO, NO_x, PM_{10}, $PM_{2.5}$, and CO from road traffic usually show parallel temporal variations.
- pollutants emitted from the same industrial source (e.g. SO_2, NO_x, PM) usually show parallel temporal variations.
- Ozone and NO are usually anti-correlated.
- NO_2 concentrations can be both influenced by NO and Ozone.

Comparison of the same pollutant at different sites

The temporal variation of pollutants is to be expected similar at sites which are influenced by similar sources, similar contributions from long-range transport or similar dispersion conditions.

A thorough comparison between pollutant levels at different site categories (urban, suburban, rural, industrial, etc.) should be performed to ensure the presence of reasonable pollutant levels among the different sites (i.e. PM levels in a region with cement industries should be higher than the levels in a background site).

Typical diurnal and weekly variations

- The diurnal and weekly cycle of road traffic emissions trigger the temporal variation of NO, NO_x, and CO, to a lesser extent NO_2, PM_{10}, and $PM_{2.5}$.

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- In coastal areas, the sea-breeze circulation can cause typical diurnal variations of concentrations, depending on the location of the monitoring site in relation to sources.
- Usually dispersion conditions are worse during night-time, which causes higher concentrations of primarily emitted pollutants.
- The diurnal variation of ozone is significantly triggered by temperature, UV irradiation and vertical transport, causing high ozone concentrations at sunny days during afternoon.

Typical annual variations

- Ozone concentrations are higher during summer compared to winter.
- Concentrations of pollutants originating from heating activities are higher during winter compared to summer.
- Usually dispersion conditions are worse during winter, which causes higher concentrations of primarily emitted pollutants.

To convert from ppb to $\mu g\ m^{-3}$, conversion factors presented in Table 6 are used.

Table 6: Conversion factors for standard conditions

Pollutant	Conversion factor at 20°C and 1013 hPa
SO_2	1 ppb = 2.6647 $\mu g.m^{-3}$
NO	1 ppb = 1.2471 $\mu g.m^{-3}$
NO_2	1 ppb = 1.9123 $\mu g.m^{-3}$
CO	1 ppm = 1.1640 $mg.m^{-3}$
O_3	1 ppb =1.9954 $\mu g.m^{-3}$

4 Data validation after information from the periodic station maintenance is available

The daily data validation may leave open questions concerning values suspicious of possible technical problems at the monitoring stations, which may require information from the station maintenance staff.
Therefore, in a second step of data validation, values are to be discarded if the periodic station maintenance confirms the malfunction of a monitoring device. These periodic visits are to be done at least once per month or as instructed by MoE.
In addition, information from the station maintenance staff can be useful to decide whether "unusual" concentrations have been caused by unusual local emissions.

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5 Final data validation

The final data validation is based on the calibration results. It can be performed after each calibration (almost quarterly) or once per year preceding the annual report.

Approximately every three months the zero and the span deviation of the analyzer are checked by the calibration transfer standard.

The results of the quarterly calibration require correction of the data (1-hour-mean values) if the zero deviation exceeds the limits given in Table 2, or the span deviation exceeds 5 % (Note: This requirement should not discourage from correcting lower deviations if considered appropriate). The correction of a negative zero drift which causes negative values is recommended in any case.

Usually, the correction is applied for the time period since the previous calibration using the function
$y(t) = k(t) * x(t) + d(t)$
with x being the original value (ppb), y the corrected value (ppb), k the span correction (%) and d the zero correction (ppb), each value as a function of time (t).
Assuming a continuous zero or span drift, the values for k and d are interpolated linearly between the value 0 at the time of the previous calibration and the zero or span deviation observed at the latest calibration.

Note: If NO and/or NO_x are corrected applying different zero and span values, NO_2 has to be re-calculated as the difference $NO_x - NO$.
In case of an identical span correction for NO and NO_x (and no zero correction), it is also to be applied on NO_2.

Handling of negative values remaining after the **final data validation** (i.e. zero drift correction):

a) Values below zero and above the negative detection limit
   - are published as "below detection limit";
   - the numeric value of these data shall be used for data aggregation (e.g. calculation of daily mean values or monthly mean values, etc.).

b) Values below the negative detection limit
   - shall be discarded as "not valid";
   - are published as "not valid";
   - are not used for aggregation (Guidance on 2011/850/EU).

Detection limits are given in Table 3.

Aggregated data (e.g. daily mean values or monthly mean values) which are between 0 and the negative detection limit shall be published as "below detection limit".

However, negative values below the negative detection limit remaining after the zero drift correction hint at a severe problem; if this is the case, the monitoring device and the calibration equipment should be checked.

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APPENDIX A

Data ACQUISITION

The primary data acquisition component is the station data logger which is used to collect primary values from the analyzer (every 5 seconds) and compute different temporal averages (10 min and hourly average for Phase I stations; 1 min and hourly averages for Phase II stations) considering the status information from the analyzer (e.g. voltage defect). The gaseous pollutant analyzers and PM monitors have their own internal data loggers which can be accessed manually to download data and transfer them to the Central Acquisition System at the MoE if needed.

The data logger collects a new value from each analyzer every 5 seconds. Those values are checked for:

- Manual mode (e.g. calibration flags, etc.): those values are not taken for further calculations
- Error status (e.g. instruments alerts, etc.): those values are not taken for further calculations
- Range of values: Values are checked if they are within the certification range of the analyzers (Table A-1).

Table A-1: Certification ranges for Phase I and Phase II analyzers

Pollutant	$NO/NO_2/NO_x$	SO_2	CO	O_3	PM_{10}, $PM_{2.5}$
Network Phase I	NO_2: 500 µg/m^3 NO: 1200 µg/m^3	1000 µg/m^3	100 mg/m^3	500 µg/m^3	1500 ug/m^3
Network Phase II	NO_2: 500 µg/m^3 NO: 1200 µg/m^3	1000 µg/m^3	100 mg/m^3	500 µg/m^3	PM10: 10000 µg/m^3 PM2.5: 6000 µg/m^3

From the valid values on the time scale of 5 seconds, the 10-min and 1-hour average (Phase I) and the 1-min and the 1-hr averages (Phase II) are calculated in parallel which means that both averages are calculated based on the 5-sec values (the 1-hr average is not calculated from the 1-min average)

Only 1-hr averages which have 75% of the values valid are considered valid and will be used for further validation and data aggregation.

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APPENDIX B

STATION MAINTENANCE - OVERVIEW

Station maintenance is performed by the operation and maintenance staff on a periodic basis at least once per month or as instructed by MoE. The maintenance staff will provide a maintenance report.

Before beginning any inspection of each station, an inspection log is initiated while recording the data of the individual tests, problems, and any other pertinent information on the inspection template sheet. Consumption of any spare and/or consumable parts during these inspections and/or emergency visits is also properly recorded to the sheet. The regular replacement of these parts follows a time schedule recommended by the manufacturer in the device user manual.

Then physical inspection of instruments is performed for the shelter unit to detect loose or broken parts, lose or damaged boards, loose fittings or connections, any damage on the sample tubes and correct operational conditions for all instruments situated in. The inspection of the supplied, installed and tested air quality monitoring equipment according to the requirements in the equipment supply contract is performed based on a checklist regarding manufacturer recommendation stipulated in each instrument user guide.

Additionally, necessary checks and tests are performed on monitoring instruments to ensure correct operation and good performance characteristic.

The operation and maintenance staff will collect raw data from the station (e.g. on a memory stick, etc.) to be used as needed to complete missing data in the central database at MoE.

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