Manual – Using the monitoring cycle

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On Monday January 16 and Tuesday January 17, 2017 a training on water quality monitoring was organized as part of Result 2.5 of the Source to tap and back (S2TAB) project.
In the training the monitoring cycle was presented, and each step was demonstrated with a Dutch example. Group work was used to work out the steps of the monitoring circle for the Ethiopian situation. The training style was learning by doing.
This is a manual accompanying the monitoring cycle.

Monitoring cycle

The purpose of monitoring is to aid Water Resource Management with information and facts. The monitoring cycle describes the steps to come from an information need to a monitoring grid and from there to reporting and utilising the information.
The cycle indicates that steps are interlinked. A monitoring grid is not a permanent fixture, but should be reviewed occasionally: Are the result of monitoring still answering the original information needs? has enough knowledge been gathered that the information needs have changed?

This manual gives some information with each step of the monitoring cycle, to help with its use.

Information needs

Information needs describes the question to be answered with monitoring.

Questions are often complex or vague, and should be simplified and made more specific.
For instance a question of 'What is the water quality in this river?' could be made more specific by asking questions about the context of the question: what do you want to know? are you interested in the suitability of the water for certain uses? Are there specific parameters you are interested in? etc.

A complex question can possibly be split into several more specific questions. This will make answering the questions more straightforward.

This step in the process is an interaction between the user of the data and the person responsible for setting up the monitoring grid.

At the end of this step you should have a clear/detailed description of the questions that need to be answered.

Monitoring strategy

Monitoring strategy describes the outline of the data collection. What is already available? Is other information available that can be used to answer the question? How will data be collected: do the measurements yourself, or obtain the info from someone else?

The questions to be answered from the previous step 'Information needs' are input for this step. In this step we check what data is already available, what additional data needs to be collected and who will be collecting the data. Are there alternative ways to collect the required information?
For each information need question:

- Check if data is already available
    - In your own organisation
    - In other organisations
- Check if the data is suitable:
    - Is it sampled at the desired location(s)?
    - is it accurate enough to be used?
- Is there alternative data available that can be used?
- If new data collection is required, consider how to collect it
    - Remote sensing?
    - Measure/analyse in the field?
    - Collect a sample and analyse in a laboratory?
- Also consider who is going to collect the data
    - Your own organisation?
    - Another agency?
    - A contractor?

At the end of this step you should have a list of data that needs to be collected and an idea who is going to collect the data.

Monitoring grid

Setting up the monitoring grid consists of the selection of locations and parameters that are going to be sampled and analysed, to be able to answer the information needs questions. The selection of locations and parameters need to fit in the available budget. Some iterations of the setup of the monitoring may be needed to get the right level of detail while making it fit the budget.

Steps to design a monitoring grid:

- Select sampling locations – draft monitoring grid
  The setup of the draft grid can be done using a map with relevant information: for instance water users, water polluters, locations of roads and bridges etc.
- Visit sampling locations
  Check if the location is suited for measurements?
  - Does it meet your requirements?
  - Is it possible to do the measurements here?
  - Is it safe to sample here?
  - Can the location be reached easily?
  - Do you need permission to get here?

  Document where samples are to be taken:
  - A proper description of the location
  - Coordinates (for use with GPS and in a map)
  - Pictures, map of the area
  - Contact information for permission (if needed)
- Make a list of parameters and consumables/necessaries:
  - What parameters need to analysed
  - What frequency is needed/how often is sampling needed?
  - Are purchases needed to be able to sample and analyse?
- Make a budget plan:
  Cost of sampling
  Cost of transportation
  Cost of analyses (laboratory days, consumables, equipment etc.)
  Cost of reporting
  …
  ---------- +
  Does it fit the budget (?)

  If it does: OK
  If not: where can adjustments be made? For instance:
  - Reduce number of locations
  - Reduce number of samples (sampling frequency)
  - Reduce parameters to be analysed
  - Increase the budget?

- Make choices if needed (budget)
  Get approval on the budget plan.

Results from the step set up a monitoring grid are:
- A monitoring grid
- A proper description of each sampling location
- A list of parameters to be measured/collected/analysed and their sampling frequency
- An approved budget plan

At the end of this step you and the user of the data agree on the monitoring grid (locations, parameters, frequency) and have an approved budget plan.

Sample collection & laboratory analyses

Sample collection and laboratory analyses are very specific tasks that are not part of this manual.

Important to keep in mind here: what is an efficient way to sample and analyse? Is each organisation doing their own sampling, or are efforts combined.
Consider sharing your sampling plans and monitoring grids with partner organisations (and other departments in your own organisation).

At the end of the step sample collection you have samples ready for laboratory analyses.
Another result of sample collection can be field measurements, like readings of level gauges. These results can move directly to the step data storage.

At the end of the step laboratory analyses you have validated laboratory results, ready for the step data storage.

Data storage

Data storage is an often overlooked aspect. When you are collecting data you know what you are collecting and a simple table (matrix of sample versus parameter) is often suited. However if you are collecting data with future use in mind, it is worth adding additional information to your dataset, making it more suited for use by others and for combination with other data.
Always make sure to add

- sample location
- coordinates
- sample date and time
- Parameter
- unit

For instance also add:

- the laboratory that did the analyses
- the analyses method used
- if the sample was filtered before the analysis
- if the value was below the limit of detection
- the value of the detection limit for the specific sample

Be as specific as possible, including on describing how a result is presented. Phosphorus for instance can be reported as phosphate (PO_4^{3-}) or as the phosphorus part (P) of phosphate. Same for the Nitrate (NO_3^-) and Nitrite (NO_2^-) and Ammonium (NH_4^+). Make sure to indicate if it is just the nitrogen (N) part or the total ion (in the Netherlands we report the different Nitrogen components expressed as the content of N, and phosphorus components as the content of P.

Table 1: Example of often use 'matrix format' or Excel presentation; not very well suited for data sharing

No	UTME	UTMN	Local Name	WP Index	EC	TDS	T	pH	NH4	Na+	K+	Ca++	Mg++	Fe total	Mn++	Cl-	NO2-
1	465578	999808	Asko BH	AA010	341	206		8,64		76	2,6	3,52	1,08			7,94	
3	469191	989547	Lebu mekanisa	AA002	309	200		7,28		22	8,3	37	11,2	0,07		5,96	0
5	471500	990500	Lafto BH 1	AA007	438	280		7		13,8	5,2	65,6	10,3			9,93	0,02
6	466601	1001250	MIKILILAND-3	AA013	147	98		6,87	0,24	12,7	4,1	13,2	2,7	0,52		1,8	
7	477715	997474	YeKA Mikayel Church	AA008	284	182		7,31		29,5	6,4	26,4	4,32			9,93	
8	463972	1000788	BH 2	AA009	280	190		8,29		50	3,7	14,1	3,24	0,29		2,88	
9	480999	999648	Salayish	AA005	464	308		7,38		62	5	33,6	8,16	0,09		21,9	0,02
10	965741	989188	Mekanisa BH 16	AA014	344	226		7,05		17	6,8	46,6	9,18	0,08		5,96	0,1
11	468261	990357	Mekanisa-19	AA015	295	194		7,71		14,5	5,7	42,2	9,18	0,04		1,99	0,5
12	487268	995400	Ayat-1	AA017	524	344		7,42	0,39	77	22	16,6	3,24	0,27		32,8	
13	470218	1001886	Belay Zeleke-2	AA018	209	138		7,61		38	4,3	9,24	2,04	0,16	0,02	5,96	
14	481462	998906	Ankorcha-2	AA019	414	272		7,24		30,5	3,2	53,8	10,7	0,28	0,05	7,94	
15	482994	998429	Luke Stream	AA020	213	142		6,87		9,8	3,4	27,7	4,59	0,12	0,1	8,94	0,14
16	484971	994879	Summit SMV- 13	AA054	1904	1394		6,5		495	24,5	25,2	5,61	0,19		47,7	
17	472608	1002066	Ketchene Meketeya	AA021	194	128		6,88		9	4,3	25,2	5,1	0,58	0,05	6,95	0,02
18	474238	1002370	Sheromeda Kidanemihret	AA022	234	154		7,74		19	7,4	22,7	4,08	0,05		7,94	0,02
19	470504	1002135	Total Belay Zeleke-1	AA023	181	128		7,34		24	5,5	12,6	2,04	0,47	0,05	1,99	0,01
21	465741	989188	Repi-23	AA027	265	174		7		10,4	4,5	36,1	9,18	0,1		2,91	
23	481519	999648	Selam Technique	AA029	422	282		7,39		55	4,6	35,3	8,16	0,29	0,05	10,9	0,01

Table 2: Example of a 'listing format' a well suited data storage and data sharing format

id	sample code	sample description	UTME	UTMN	sample date (european)	sample date (ethiopian)	sample time	parameter	unit	filtered	watertype	value	sign detectionlimit	Analyses method used	source	date of analysis (European)
1	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	EC	ms/m	no	lake	147		Wagtech_EC	EU WFF	07-05-23
2	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	TDS	NTU	no	lake	[illegible]		DR/2010_prog_630	EU WFF	0[illegible]
3	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	T	oC	no	lake			Wagtech_T	EU WFF	0[illegible]
4	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	pH	-	no	lake			Wagtech_pH	EU WFF	0[illegible]
5	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	NH4	mg/l	yes	lake			titration_X	EU WFF	0[illegible]
6	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Na+	mg/l	yes	lake			photo_80002	EU WFF	07-05-23
7	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	K+	mg/l	yes	lake			photo_80003	EU WFF	07-05-23
8	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Ca++	mg/l	yes	lake			photo_80004	EU WFF	07-05-23
9	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Mg++	mg/l	yes	lake			photo_80005	EU WFF	07-05-23
10	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Fe total	mg/l	yes	lake	0,52		photo_80006	EU WFF	07-05-23
11	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Mn++	mg/l	yes	lake	0,01	<	photo_80007	EU WFF	07-05-23
12	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	Cl-	mg/l	no	lake	1,8		DT_921-01	EU WFF	07-05-23
13	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	NO2-	mg/l	no	lake	0,02	<	photo_80009	EU WFF	07-05-23
14	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	NO3-	mg/l	no	lake	0,52		photo_80010	EU WFF	07-05-23
15	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	F-	mg/l	no	lake	1,4		photo_80011	EU WFF	07-05-23
16	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	HCO3-	mg/l	no	lake	87,84		titration_1	EU WFF	07-05-23
17	EX007	Example samplepoint	466601	1001250	24-4-2013		14:00	CO3--	mg/l	no	lake			titration_2	EU WFF	07-05-23

river
spring
lake
deepwell
borehole
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At the end of the step data storage you have the monitoring results in a suited format, preferably in a database, with all the additional info needed so others can also understand how the data was collected and analysed.

Data analysis

The step data analyses involves checking the data to see if it is complete and if the values are plausible (within the limits to be expected). Other steps of data analyses can be aggregating data for instance statistically, or testing for trends or compliance with water quality standards.
The data aggregation steps of course specific to the needs to answer the information needs questions.

Data validation:

- Is the data complete
  Check if all the results are in the database.
- Are the results plausible (within the limits to be expected)
  As part of the analyses the laboratory will check if the analyses went well and if the results are within the range for the test. The laboratory analyses does not necessarily involve cross checking with previous test results or with other tests or field results.
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Data aggregation:

- Statistically
  (minimum, maximum, average, etc.)
- Testing against water quality standards
  If needed to answer the information need, results can be tested against water quality standards for different water uses (drinking water, irrigation) or an environmental standard.
  The EU water framework directive sets environmental water quality standards in which annual average and maximum concentrations are tested against their respective standards. It is not typically the testing of each individual sample against the standard.
- Trend analyses
  If enough data is available (at least 3 years of data over a 5 year period) it is possible to do statistical trend analyses. If more data is available, trends can be detected more accurately.

At the end of this step the data is complete and valid and has been enriched with additional data like statistical data or results of water quality testing. The data is ready for reporting.

Reporting

Reporting can be done in different ways, amongst others as a plain dataset, a report on paper or softcopy, a scientific or popular article or even on mass media (radio, TV) or social media.

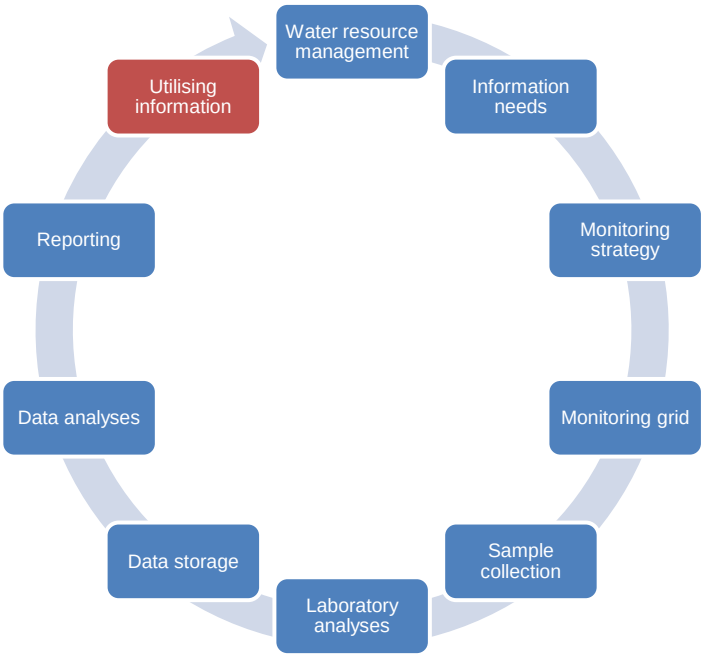
In the monitoring cycle reporting is intended as the step to answer the questions from the step information needs. It is fact based, based on the freshly acquired results.
Several options for reporting to the user:

- Plain dataset
- Report (analogue/digital)
- Articles (scientific, popular)

Answer the original questions (information needs).

At the end of this steps the facts are reported back and the original questions are answered. Recommendations on changes to the monitoring grid can be included.

Utilising information



The final step in the monitoring cycle is utilising information. If you have reported something, how do you make sure the results are shared and disseminated to the relevant stake holders? How to resort effect with the results of monitoring.
This step is very closely related to water resource management and will typically be a team effort of data user and the person reporting the data. A good first step is to publish or share the report with the monitoring results to colleagues within your own organisation and other government agencies.
Steps to add impact include adding examples and interpretations.

At the end of this step the monitoring has not ended up in just another report, but data has been turned into information, shared and put to use.