Video « Metrology – The bias »

Time	Text
00 :08	This video is about the error of a measurement and so, by extension, the accuracy of a method. We are going to present different manners to reveal the error.
00 :23	Firstly, this cartoon is illustrating the notion of error. It is about two analytical chemist cowboys in the wild west. One of them wants to shoot the other and says: “Watch out, I will shoot you with this percentage of load, this percentage of cobalt, silver, antimony etc.”, with the values more or less accurate. The other cowboy answers: “Wait a minute, are you sure that the values are certified ?”
01 :02	So, we will talk about this. In these “certified values”, there is the notion of accuracy of the measurement: we have to be sure that there is no difference between the value that we have measured and the true value of the sample.
01 :15	So, the error of a measurement, as we understood with the notion of accuracy, is the difference between the result of the measurement and the true value of the sample. Usually, the laboratory uses the mean of several measurements of the sample obtained with the same method.
01 :34	In the error of measurement, there are in fact two types of error with a different origin: - First, there could be an error from the used method itself. Indeed, the method could have some defaults and, in that case, will introduce systematic errors in the result of the measurement - Moreover, it could be an error from the laboratory. It means that the method is correct, but the person from the laboratory who is using this method will make some mistakes and therefore will introduce some errors in the result. For example, the error could come from a bad rinse of the material, some losses of the sample or because of contamination of the sample
02 :22	There are several tools which allow to reveal these two types of error: - When the error is from the method, like we will explain in this video, we can calculate the recovery rate by adding some solution to the sample; we can also use some referenced solutions or materials and we can compare the result of our method with the result of a validated method for which we are sure there are no errors in the measurement, therefore it will be possible to know if there are any errors in our method. - When the error is from the laboratory, there is only one manner to reveal it: the laboratory has to take part to inter-laboratory tests. During these tests, the laboratory will compare its results with the results of the other laboratories and will be able to know if there are some errors due to its way to proceed. Some examples will be presented in this video.
03 :14	Let’s sum up the different methods for revealing an error of a measurement: - First, it is possible to calculate the recovery rate - Then, referenced materials can be used - The comparison with a validated method won’t be illustrated in this video but the principle is really simple. For the same sample, the measurement is done twice: the first time by using the method we want to test, and the second time by using a validated method for which we know there are no errors in the measurement. Then the results obtained with each method are compared. - Finally, the principle of inter-laboratory tests will be explained as well as what types of result are expected from these tests.
03 :48	Let’s begin with the calculation of the recovery rate. This method is used in the laboratory to reveal an error linked to the method of measurement. The principle is simple: first the samples are measured (usually, there are triplicates for each sample in order to have three different values of the measurement), then, for the same sample, a known quantity of the wanted molecule is added (again, usually triplicates are using). So,

	a measurement is performed on the same sample before and after the adding. This will allow to estimate a recovery rate, often calculate as a percentage. To calculate it, the sample concentration before the adding is subtracted to the sample concentration after the adding, and the result of this subtraction is divided by the known concentration which has been added to the sample. This will give a recovery rate and will allow to know if we recover 100% of the added concentration or not. This method will allow us to assess the recovery rate and to know if there are manipulations in the measurement method which introduce some errors, which would be revealed by a loss in the adding concentration.
05 :11	But, this method cannot be used as an estimation of an extraction yield in the case of extraction method. Indeed, especially for solid matrix which are heterogeneous, a bit complex and for which the interactions with the molecule wanted to be extracted are strong; the interactions with the adding solution will be simpler and weaker, therefore the adding solution is easier to extract. So, this method allows to assess recovery rate but not extraction yield.
05 :45	This is an example of results obtained for the analysis of aflatoxins. Aflatoxins are mycotoxins which toxins produced by mould in some food. In the blue rectangle are presented the different types of aflatoxins and the tested matrix. Then, there are the name of the organism which has validated the method. Then, in the orange rectangle, the tools used for the measures are presented. Finally, what we are interested in is presented in the red rectangle. Here, the method performance is presented. So, the recovery rate could be find in percentage, which has been estimate as we explained previously. In this table, there are also the uncertainties, named as RSD, relative to the repeatability r and the reproducibility R, which give an idea of the precision of the measure. To know more about this really important notion, you can watch the video about accuracy and precision.
06 :59	The second manner to reveal the error is to use a validated material. Here, there is an example of a validated material which is a certified material. Again, there is a video which explain what are validated materials: What are they? What are they used for? So, you can watch this video if you want more detail concerning this type of tool to assess the error.
07 :24	So, in this table there are certified values, which means true values, of concentrations which have been determined for two materials, which is milk powder in each case. And then, for each type of material, there different organochloride pesticide and different concentrations with a precision which has also been estimated for these certified values.
07 :48	The last manners to assess a measurement error is to take part into an inter-laboratory tests. Usually, these tests are used to reveal errors from the laboratory. Here, there is an example of an inter-laboratory test concerning the mercury analysis which is a toxic metal often found in the fish. In that case, fish filet has been analysed. On the graph, the abscise axis represents the laboratories which have participated with, for each, some elements on the method they used for the mercury analysis in the fish filet. Obviously, laboratories are represented with number to stay anonymous. The same sample has been measured by all the laboratories, so there are supposed to find the same result. Therefore, on the graph, the y-axis represents the concentration of mercury and each point represents the result of each laboratory. Each point is the mean value of several measurements of the sample performed by each laboratory and then the 95% confident interval is represented around this mean.
09 :04	So, after an inter-laboratory test, a statistical analysis is performed on the results and limits, called z limits, are created. I won't give too many details, but roughly the z limits are indicators which allows to assess the performance of laboratories according to

	difference between their measurement of the sample and the true certified value. So, boundaries of rejection are created. Here, the boundary if for z equals to plus or minus two. So, if the labs are above this limit, it means that they probably have an error and they have to apply a corrective method. If they are above the limit of z equals to three, they completely rejected and it means that there is a real problem in the measurement method of the lab.
09 :53	In this example, there are some labs which are between the limits of z equals to two and z equals two three and there are some which are out of the boundaries et which really above three.
10 :02	But, with these tests, the aim is not to tell to the laboratories « You are doing bad work and you are not competent ». The objective is to give the results to the laboratories and to discuss with them, to exchange in order to find the origin of the error, because there could be several different origins. And then, to do new tests with a corrective method in order to improve the results of the laboratories in a new tests inter-laboratory.
10 :34	Sorry, I forgot to mention that the error could be due to a problem in the calibration, a contamination of the reagent by the mercury so it will change the value measured by the laboratory or procedure of sample treatment (as mineralisation or digestion) which are incomplete and therefore won't recover all the mercury present in the sample.
11 :00	To illustrate the use of these test, here is another example. In that case, the test is easy. It is a standard solution of heterocycle amines which are molecules formed during the cooking of the meat and which are carcinogenic and mutagenic. Therefore, it is very important to be worried about their presence in the food for which they could appear during the cooking. This analysis is a little bit tricky because there are a lot of molecule at low concentration.
11 :32	So, here the idea of this test is to help the laboratories who participate to this test to improve their skills in the analysis of this type of toxic molecules in the food. Here, the first testing which has been performed is a standard solution which is supposed to be analysed easily.
11 :48	These are the results of the first testing. Obviously, there is the standard solution which had been prepared by the organizer of the test, so, the true values of concentration for each molecule are known. In this table, each line represent a molecule from different heterocycle amines. Then for each molecule, there are the true value of the concentration and the concentration measured by each laboratory as well as the confidence interval which reveal the precision of their measurement.
12 :15	Thanks to the results of the first testing, it appears that there were bias due to a systematic error which was linked to a calibration issue or a wrong quantification of the molecules. So, the different laboratories met each other and tried to build a corrective method to improve their results. Then a second testing was organized with a new standard solution to analyse. As shown in the table, the laboratories got better results and were closer to the true value of the sample with a better precision, thanks to the corrective method.
12 :48	So, this is how the inter-laboratory tests work. Thanks to them, it is possible to find the origin of bias and then to build some corrective methods in order to delete all the bias of the process.
13 :01	Here, there is an example for aromatic heterocycle amines with a target concentration in the test solution at 1.44 µg/L. As you can see, the results of the first test were not satisfying. Again, L1A, L1B etc. represent the different laboratories, points are the mean value obtained by each laboratory with their 95% confidence interval associated. The target value is represented by the dots. The dots on the left represent the general mean which has been calculated from the results of this first test after a statistical analysis of the results obtained by the laboratories.

Video « Metrology – The bias »

13 :52	So, we can understand that there is a common bias linked to these bad results of the laboratories. For the second test, the corrective methods allowed to improve the individual result of each laboratory as well as the general result of the test inter-laboratory. Indeed, the general mean calculated from the results of all the laboratories is closed to the true value. Therefore the bias in the results has been deleted.