A benchmarking study on information management systems for water laboratories in South Africa

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Abstract

The increasing demand for the chemical monitoring of water qualities emphasises the importance of an efficient and workable laboratory management system to remain profitable and competitive in a fast growing industry. The management of information is therefore becoming increasingly important as the effectiveness and profitability of the water laboratory is largely measured against its management systems and continual improvement programmes. Effective information management forms an important part of laboratory management to ensure that data are updated and remain current. One way of proving its effectiveness, the laboratory must provide proof of a controlled and procedurised documentation system and the availability of updated data and information. The effective control of data and information in the water laboratory by using some kind of information management system is therefore essential. Laboratory managers are becoming aware of the need for an effective, computerised laboratory data and information management system as the entry of data and results into a manual system has several disadvantages. The laboratory manager is increasingly seeking for ways to improve the efficiency of his laboratory and more time must therefore be spent on managing the laboratory, rather than to facilitate the distribution and control of information.

Introduction

The modern water chemistry laboratory in developing countries is equipped with state-of-the-art equipment and suitably qualified and skilled personnel to ensure that laboratory test results are reported timeously and accurately. Critical analytical equipment is linked to the Laboratory Information management System (LIMS) and data entry is automated. Laboratory documentation forms an important, integral part of the laboratory and it is essential that documents are effectively controlled. All the documents which are kept in the laboratory are recorded on a master list and clear distinction is made between original copies and revised copies. Only authorised personnel are permitted to instruct any amendments, alterations or revisions to laboratory documents. Documents are numbered and located and periodically revised by management. Obsolete documents are removed from the system (SABS ISO/ IEC17025: 2000).

Current status of information management in water chemistry laboratories in South Africa

Generally, South African water laboratories compare favorably with their international counterparts with regard to laboratory information management systems. It is common knowledge that LIMS is designed primarily for the collection, processing, storage and retrieval of laboratory data and results. Information is stored in electronic format with rapid manipulation of laboratory data and the printing of documents and test reports. Smaller water laboratories without LIMS normally rely on the manual operation of the following activities:

- log-in of sample details and planning and scheduling of workloads;
- labelling of samples and entering of data and test results;
- equipment availability and performance;
- final quality control of test results;
- tracking of samples and sample results through the laboratory;
- construction and presentation of graphs and trends; and
- reporting of results to customers.

Manual systems subsequently have no definite and guaranteed control over the scheduling of water samples and sample turn-around times. Larger laboratories on the other hand are mostly equipped with some type of LIMS for the registering of samples and the reporting of results. LIMS is an effective tool for automation of the water chemistry laboratory. These systems are designed using the correct and appropriate criteria in order to meet the current and future needs of the water laboratory and its customers and stakeholders.

Requirements for international competition

In order for laboratories to remain internationally competitive, effective measures must be implemented to ensure that information and data management systems incorporate, *inter alia*, the following core functions (Gillespie, 1995; Paszko, 2001; Miller, 1997; Oelker, 1997, and Kolva, 1995):

- sample scheduling, archiving and tracking;
- access to validated methods and standard operating procedures;
- interfacing to a wide spectrum of laboratory instrumentation and providing the status of equipment;
- traceability and status of test samples and test results;
- flagging and/or rejection of out-of-specification results and acceptance of approved and verified results;
- graphical presentations of analytical data, equipment performance and personnel productivity;

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- automatic statistical manipulation of test results and final quality control to verify the quality of test results;
- electronic data capture and transfer and the color graphical presentation of summary statistics and test reports;
- e-mail facilities for the automated electronic transfer of data to customers; and
- allocating of passwords to authorised users to assure the confidentiality of information.

Benchmarking

LIMS is not faultless and its functionality and performance is largely dependent on the skills of the operator and the information fed into the system. Benchmarking (Chase and Aquilano, 1992) is the singling out of a process or activity of the LIMS and the assessment of the LIMS employed by a similar laboratory in the water industry to find ways to improve the effectiveness and overall performance of the system. Benchmarking is therefore a vital tool to seek for the ideal system in order to implement the most effective and compatible LIMS that would lead to high laboratory standards and add value to stakeholders' growth.

Benchmarking LIMS in the water laboratory

Benchmarking of LIMS in water laboratories includes the following parameters (Delport, 2001; and Erasmus, 2001):

- the user-friendliness of the system;
- assessment of the effectiveness of management information;
- the compulsory use of validated methods and procedures by all laboratory personnel;
- the accelerated speed of operation;
- the logical layout and presentation of reports and data;
- the ease of programming; and
- the compatibility with instrumentation and computers.

Benchmarking study

Four large water laboratories in South Africa were evaluated for specific parameters with regard to the use of their LIMS. These parameters/uses of LIMS and the results of the survey are reflected in Table 1.

Conclusions from benchmarking study

A growing demand for a computerised system integrating all aspects of safety and environmental management, manpower administration, manpower training and development, and quality management in the modern water laboratory is evident.

The following conclusions can be derived from the survey:

- The LIMS used by all, or the majority of the participating laboratories, facilitates the general requirements of LIMS used by most water laboratories, such as the registering of samples received, the manipulation and traceabilty of results, equipment management, and internal and external quality control;
- None of the LIMS used by the participating laboratories caters for manpower training and development management, safety and environmental management, asset and inventory management, non-conformance management, audit and review management, management of suppliers and subcontractors, change management, and customer complaints, confidentiality and communication management.
- Separate systems are implemented at all, or a majority of, the laboratories for safety and environmental issues, manpower administration, manpower training and development, and quality management. None of the laboratories have integrated these elements of management with the LIMS.

The Integrated and Sustainable Laboratory Management System (ISLMS)

The ISLIMS is designed to suit the requirements of the laboratory and facilitates the generation of all documents relating to the normal operation and performance of the laboratory. The ISLIMS is a computerised system which goes far beyond the conventional laboratory information management system. The system provides the laboratory manager and his personnel with rapid and easy access to all laboratory information and documentation.

Elements of the ISLIMS

The main components of the ISLIMS are as follows:

Laboratory organisation

- Laboratory organisational and management structures;
- Laboratory mission, policies and objectives;
- Laboratory management activities;
- Laboratory layout design;
- Laboratory structures;
- Management appointments;
- Job descriptions/job profiles;
- Salary details; and
- Job details.

Personnel training and development

- Training requirements;
- Training programs;
- Training modules in line with training programs; and
- Training methods.

Quality control (SABS ISO/IEC 17025: 2000)

- Sample management:
  - Status and origin of water samples received;
  - Water sampling programme and
  - Handling of test items.
- Inventory of different analyses performed in the laboratory;
- Inventory of validated test methods available;
- Equipment management:
  - Equipment calibration programmes;
  - Maintenance, procurement, replacement and disposal;
  - Equipment operation; and
  - Equipment monitoring.
- Reporting of test results;
- Laboratory quality control programme:
  - Summary statistics;
  - Internal standards available;
  - Proficiency testing (ISO/IEC Guide 43 International Standard, Parts 1 and 2 of 1997);
  - In-house quality control system;
  - Certified reference materials available; and
  - Control charts in use.

TABLE 1
Results of a benchmarking study on four water laboratories in South Africa with regard to the use of a LIMS

Parameter	Laboratory evaluated			
	1	2	3	4
a. Access to personnel job descriptions, salary details and job details	N	N	Y	N
b. Sample scheduling, archiving and tracking	N	Y	Y	Y
c. Access to validated methods and access to SOP's for SMEQ activities	N	N	Y	N
d. Access to SMEQ manuals	N	N	Y	N
e. Status of equipment calibration and maintenance	Y	Y	Y	Y
f. Traceability and status of test samples and results	Y	Y	Y	Y
g. Rejection of out-of-specification results	Y	Y	Y	Y
h. Acceptance of approved and verified results	Y	Y	Y	Y
i. Statistical manipulation of results	N	Y	Y	Y
j. Inventory and pricing of analyses	Y	Y	Y	Y
k. Inventory of certified reference materials	N	N	N	N
l. Availability of and access to personnel training requirements, programmes, modules and results	N	N	N	N
m. Access to accredited training material	N	N	N	N
n. Management of proficiency testing	N	Y	N	Y
o. Use of control charts	N	Y	Y	N
p. Safety management	N	N	N	N
q. Management of hazardous materials	N	N	N	N
r. Emergency preparedness and response plans	N	N	N	N
s. Waste disposal management	N	N	N	N
t. Identification and description of SMEQ non-conformances	N	N	N	N
u. Access to laboratory audits and reviews	N	N	N	N
v. Asset and inventory management	N	N	N	N
w. Financial management	N	Y	N	N
x. Management of suppliers and subcontractors	N	N	N	N
y. Change management	N	N	N	N
z. Customer complaints, confidentiality and communication management.	N	N	N	N

Key: **SOP:** Standard Operating Procedures
SMEQ: Safety, Manpower, Environmental and Quality
Y: Yes, the laboratory uses this LIMS function
N: No, the laboratory does not use this LIMS function

Safety and environmental programme (NOSA, 1997; NOSA, 1992; and ISO 14001, 1996)

- Laboratory safety practices;
- Environmental legislation;
- Safety and environmental plans, targets, programmes and initiatives;
- Safety and environmental training;
- Control of environmental conditions and activities;
- Controlling, handling, issuing, transporting, storing and safe disposal of dangerous and toxic chemicals and liquids;
- Identification and witnessing of dangerous experiments and work activities;
- Emergency preparedness and response plans and programmes;
- Access control to chemical store-rooms, poison cupboards and restricted laboratory areas;
- Waste disposal; and
- Personal protection.

Safety, manpower training, environmental and quality (SMEQ) documentation

- SMEQ manuals;
- Laboratory reports;
- Laboratory records; and
- Test certificates;

Laboratory audits and reviews

- Audit and review programmes;
- Audit and review elements;
- Audit and review results; and
- Proposed action plans to be implemented.

Non-conformances
Corrective actions
Continuous improvement programmes

Functionality of the ISLIMS

ISLIMS is designed to integrate the laboratory's safety, manpower, environmental and quality management systems with the LIMS in use by the laboratory. The system is used by applying either the main menu or the search facility. The keywords or concepts contained in the ISLIMS are numbered in a chronological manner to ease the retrieval of any concept, activity, document or process. The main laboratory management features consist of the following options:

Laboratory management

ISLIMS deals with the following main elements of laboratory management:

- Personnel administration
- SMEQ management systems
- SMEQ documentation
- Laboratory assessments
- SMEQ process and system monitoring and control
- Deviation and non-conformance
- Continuous improvement.

Search facility

The SEARCH facility enables personnel to locate any file, document or manual with cross-references by entering a keyword into the SYSTEM.

Level of authority

The level of authority option is a password-protected configuration that provides direct access to all database files by authorised users. A "r**ead"** option restricts the operator to the reading of a document, while a **"write"** option enables the operator to read or to amend any document or file.

Security

Proper back-up arrangements are essential for the protection and securing of data and information stored on ISLIMS. Back-up applications and data are transferred to magnetic tapes using standard back-up software. Back-up copies are made on a daily, weekly, monthly and year-end basis. These magnetic tapes are kept secure in a laboratory safe. All ISLIMS data and information is protected by passwords which are entered before logging into the file server and main system.

Conclusions

Managing the modern water laboratory requires more inputs from the laboratory manager and more advanced systems than were required previously. The laboratory manager more and more fulfils the roles of safety and environmental, manpower, and quality manager.

The effective control of data and information is therefore essential to ensure the effectiveness of all the systems and operations of the laboratory. Integrating the main laboratory management systems reduces the volume of paperwork and will avoid the duplication of documentation. The ISLIMS is designed to integrate the quality, manpower, safety and environmental, and manpower training systems of the laboratory. The program caters for the easy and rapid storage and retrieval of information, data and documentation. The system can be used by applying either the main menu or the search facility and enables personnel to enter a key word or topic into the computer or to click on a coded number allocated to the key words. The program automatically provides the required information. ISLIMS also attempts to facilitate the documentation of accredited water laboratories.

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