

## **Erosion and sediment transport in South America. Monitoring programmes and strategies**

G. ARDUINO

Instituto de Mecanica de los Fluidos e Ingenieria Ambiental, Facultad de Ingenieria. Direccion Nacional de Hidrografia. Ciudadela 1414. Piso 3. Montevideo, Uruguay

### **INTRODUCTION**

In April of 1989, the Working Group on Hydrology of the Regional Association III had its last meeting. During the discussions that were carried out the sediment transport problems were highlighted.

During the last Meeting of the Regional Association III (South America) of the WMO the report of the Working Group was analyzed and it was decided to reinstall the Working group on Hydrology of the region, including the subject on sediment transport. This meeting took place in Quito, Ecuador, in October 1989. This is the first time that the subject on sediment transport is included at the regional level in South America in the framework of the WMO.

The responsibility to prepare a survey and a report for the next meeting of the Working Group was given to Mr. David Perez (Venezuela) and to the author of the paper. The next meeting will take place in Montevideo during the first months of 1993.

The present paper is based mainly on the activities carried out in the framework of the Working Group. Information on the subject of the paper was also obtained in the visits to different countries that were done during the last years.

This paper only deals with erosion as a source of sediments that can be transported by the streams.

### **ANTECEDENTS**

At a regional level, there are not many previous reports dealing with monitoring programmes. One of the most interesting is the report prepared by Mr. Humberto Pena (Chile), about hydrological networks. The networks include sediment transport stations. The report is focused in monitoring programmes with the approach given by the Guide to Hydrological Practices (WMO, 1983). In the present edition of the Guide the design criteria is given by means of percentage of the water measurements stations.

Objective oriented monitoring programmes can be found in South America at a country level. One example is the programme prepared in the framework of the project URU 87/007 -UNDP/WMO- (de Vries, 1987). There is also a identification of the need of a programme for navigation purposes at the rivers Parana-Paraguay.

### **PREPARATION OF THE SURVEY**

At the end of 1989, the President of the Working Group on Hydrology of the Regional Association III, send to all the rapporteurs a letter suggesting the activities to be carried

out, and asking for a working plan for each subject. In the case of sediment transport, as there are two rapporteurs -as has been mentioned above-, it was necessary to coordinate. This coordination was done by correspondence and also during the International Symposium on Major Latin American Rivers that took place in Ciudad Guayana Venezuela, in May 1990. A first draft of the questionnaire was prepared and discussed with the President of the Working Group. Other opportunities to make indirect coordination were the Meeting of the National Committees for the International Hydrological Programme of UNESCO, Montevideo, November 1990 -in which the delegate from Venezuela brought information given by the co-rapporteur, and the World Meteorological Congress -in which the author of the present paper could coordinate with the corapporteur through the Hydrological Advisor from Venezuela.

### The Questionnaire

In October 1991, the Secretariat of the WMO circulated the questionnaire among the 13 countries of South America.

A condensed version of the questionnaire is given below:

1. Country: \_\_\_\_\_ Date: \_\_\_\_\_.
2. Person completing the questionnaire: (including Name, Position, Institution and Address).
3. Are measurements made in your country on the following?  
Suspended sediment load  
Bed load total ST
4. Which institutions make ST measurements?
5. Are the measurements made at national level or in certain basins.
6. Observing network
 

	Suspended sediment	Bed load
No. of Stations _____	YES / NO _____	YES / NO _____
Continuous obs. _____	YES / NO _____	YES / NO _____
Occasional obs. _____	YES / NO _____	YES / NO _____
Discharge data _____	YES / NO _____	YES / NO _____
Other hydraulic data _____	YES*/ NO _____	YES*/ NO _____

\* If the answer is "YES", which types?
7. Are direct measurements made to determine bedload?
8. If the answer of question 7 is "YES", are the measurements made from a bridge?
9. If the answer to question 8 is "YES", would they be improved if made from a boat?
10. Instruments used in your country (if possible, give both type and model)
  - (a) Suspended sediment
  - (b) Bedload
  - (c) Bedload samplers
  - (d) Others
11. Are any ST measurements made which are not related to the instruments covered in question 10?
12. Do the institutions have their own laboratories?
13. Are the laboratories adequate?
14. What laboratory measurements are made?
15. What standards are used in making these measurements?

16. In the case of bedload, are dunes present as a form of transport?
17. Are time series on ST generated?  
For suspended sediment load  
For bedload
18. If the answer to question 17 is "YES", what length of time series is available?  
For suspended sediment load:  
1-5 years                      5-10 years                      15-20 years                      >20 years  
For bedload:  
1-5 years                      5-10 years                      15-20 years                      >20 years
19. Is it planned to generate time series on sediment transport?
20. Is a mathematical model used in relation to sediment transport?
21. A mathematical model exists, but is not calibrated.
22. Is there a need for a model on ST?
23. Has a model on ST been obtained through HOMS?
24. Is ST modelling being studied at national level?  
If the answer is "YES", which institutions are making the studies?
25. How many people are involved in ST measurements (including both part-time and full-time)?  
Field & office, Laboratory, Technicians, Professionals
26. Is ST included on training courses for professionals?
27. Have HOMS components been requested on ST-related subjects?  
If the answer is "YES", which components?
28. Have HOMS components been obtained on ST-related subjects?  
If the answer is "YES", which components?
29. Have HOMS components been used on ST-related subjects?  
If the answer is "YES", which components?
30. Are any ST-related problems encountered as regards:  
Shipping, Sedimentation of reservoirs, Water erosion below reservoirs, Water withdrawals, Extraction of materials, Water treatment, Local protection of banks, Others (specify)
31. Are data obtained on reservoir sedimentation?
32. Are cohesive sediments a problem in your country?
33. If the answer to question 32 is "YES", are there any connections with tidal phenomena?
34. Is it planned to start ST measurements?  
If the answer is "YES", which measurements?  
If the answer is "YES", are there concrete plans?  
When will the measurements be started?
35. What are the most important causes of erosion and sediment production in your country?  
Agriculture                      Roads                      Sea currents                      Freezing  
Urban development                      Fires                      Natural erosion                      Mining  
Deforestation                      Others

The aim of the questionnaire was to identify problems. There are cross questions in order to be able to have an idea of the quality of the answers.

### The Answers

The deadline for the submission of the answers was the 30<sup>th</sup> November of 1991. At the

end of January of 1992, six countries send their answers: Colombia, Ecuador, Guyana, Paraguay, Peru and Uruguay corresponding to the 46% of the countries of South America (Fig. 1). If the answers are weighted with the surface of the countries, the percentage is reduced to almost 20%. The importance of Brazil and Argentina for this survey has to be kept in mind as they represent the 63% of the surface of the sub-continent.

### CONCLUSIONS

A summary of the result of the survey is given in Table 1. In only one of these six



FIG. 1 Countries in South America that have answered the questionnaire (shaded).

TABLE 1 No. of sediment transport stations according INFOHYDRO (1987) and present survey.

Country	INFOHYDRO	Survey
Argentina	81	
Bolivia	32	
Brazil	250	
Chile	28	
Columbia	289	300
Ecuador	32	231
French Guyana	3	
Guyana	0	10
Paraguay	-	0
Peru	25	-
Suriname	8	
Uruguay	0	5
Venezuela	424	

countries that have answered the questionnaire, one can conclude that the person that completed the questionnaire has a good knowledge of the sediment transport problems. In the other cases, there is a lack in information of :

- a) mechanisms of sediment transport;
- b) research carried out in other institutions inside the country
- c) lack of information of sediment transport programmes carried out in other institutions.

In some countries the author has no mean to verify the information with the actual situation in the country.

The fact that the development of the erosion and sediment transport monitoring programmes has started only few years ago may be explained by the lack of good water quantity networks.

More detailed conclusions can be obtained but these conclusions are beyond the scope of the present paper. Before the meeting of the Working Group on Hydrology in Montevideo (beginning in 1993), a more thorough report will be prepared.

## STRATEGIES

In the publication WMO/UNESCO (1991) Chapter 5 deals with "a strategy for the 1990s". The scope of this publication is the whole subject of water resources assessment. Four strategy components have been identified:

- a) financial resources,
- b) institutional arrangements,
- c) technology transfer,
- d) human resources.

From this four components it is felt that the last one, human resources, is in South America not a problem itself. Reading IAHR (1990), it can be concluded that there are in South America human resources with good training. The problem is that most of the time they are not involved with monitoring programmes.

Regarding technology transfer, it can be said that the efforts conducted through HOMS (Hydrological Operational Multipurpose System) are very valuable. The Reference Manual (WMO (1988)) gives information about the system. UNESCO recognizes HOMS a major mean of technology transfer (UNESCO, 1990).

Institutional arrangements seems to be the most important topic to pay attention. At present there is a lack of coordination that makes it difficult to take advantage of skillful human resources. During the recent International Conference on Water and the Environment, Dublin, January 1992, the institutional problems have had much more importance than in the previous United Nations Conference on Water, Mar del Plata, March 1977.

In reference to financial resources it is felt that having good designed monitoring programmes (objective oriented), funding will be available.

One very interesting approach to the problem of erosion and sediment transport monitoring at the regional level for South America is to carry out an evaluation of water resources assessment in each country. The publication UNESCO/WMO (1988) describes this activity. In the meeting of National Committees of South America, Central America and Mexico for the International Hydrological Programme of UNESCO held in Montevideo in November 1990, developed the same recommendation (No. 5) (see UNESCO (1990)). Few countries have yet finished or initiated this activity.

To have a closer relation between monitoring programmes and the use of the information obtained seems to be one of the most important ways to improve the results. The design of the programmes taking into account the objectives as the first step ought to be the normal procedure. An increase of coordination between people responsible for obtaining basic information, users and planners and experts in the field of modeling could be the way. The Dublin Conference gave a great importance to the follow up of the programmes.

The publication of a book entitled "Sediment Engineering in Developing Countries", supported by UNESCO, may be also a way to improve monitoring programmes. In the same way will help the work of the CHy regarding the subject on sediment transport.

The discussion of the subject in meetings like the present Symposium, for example to introduce modifications to the questionnaire, may be another way to achieve an improvement.

To carry out a survey like that mentioned above, it would be convenient to involve also the National Committees of the IHP. In most of the committees of South America there are experts from all the sectors involved.

To continue the present activities within the Working Group on Hydrology of the RA III (South America) and to expand the information sources seems to be a practical way to improve monitoring programmes.

**ACKNOWLEDGEMENTS** Mention is made to Mr. Tabare Palas, President of the Working Group on Hydrology of the RA III for his advice in preparing the paper. Also a mention is made to Mr. David Perez, corapporteur on sediment transport of the Working Group; with him was the survey prepared. Also the Secretariat of the WMO, specially Mr. Dieter Krämer, has to be mentioned for the support given to the activities related with the sediment transport problems. With Mr. Carlos Fernandez-Jauregui, from the Regional Office from UNESCO in Montevideo, an interesting discussion about the subject of the paper was held.

REFERENCES

- de Vries, M. (1987) Report on Mission on sedimentology. WMO/UNDP Project URU 87/007 "Hydrology for Development in Uruguay".
- IAHR (1990) Memorias del XIV Congreso Latinoamericano de Hidraulica. Montevideo - Uruguay.
- UNESCO (1990) Hydrology and water resources for sustainable development in a changing environment. Detailed plan for the fourth phase of the IHP (1990-1995) as approved by the IHP Council at its Ninth Session, Paris, March 1990).
- UNESCO (1990) Informe Final de la Reunion de los Comites Nacionales del Programa Hidrologico Internacional de America del Sur, America Central y Mexico.
- UNESCO/WMO (1988) Water resource assessment activities. - Handbook for national evaluation.
- WMO (1983) Guide to Hydrological Practices. WMO-No.168.
- WMO (1988) HOMS Reference Manual.
- WMO/UNESCO (1991) Water resources assessment. - Progress in the implementation of the Mar del Plata Action Plan and a strategy for the 1990s.