A study into the bed load of the river lemon essay sample

Rivers dominate the landscape all over the world, producing widespread changes and affecting human and physical environments in many ways. Rivers are hugely variable because of factors such as climate, geology and human influences, but most follow similar patterns and have similar processes. Understanding these processes is essential for humans to live in harmony with rivers, and knowing how best to use and manage them. To understand these processes we can study river variables, such as velocity, efficiency and discharge, and how they change along the river's course.

In this investigation I will try to find out how river variables change downstream in relation to the bed load. The bed load of a river is the material that sits at the bottom of the channel. The bed load is composed of material that is too heavy for the river to entrain and carry along the channel, this is mostly rocks. The bed load originates from two sources: 90% is exogenetic, coming from weathering and mass movement of slopes near the river. 10% is endogenetic, coming from the river's own channel. Understanding the bed load is important as it affects the characteristics of the river as a whole and therefore the management of the river. For my investigation I have studied five sites along the course of the River Lemon in South Devon. I have two key questions to guide my investigation:

1. In what ways does the bed load change downstream?

2. Is there a correlation between river velocity and the size and angularity of the bed load?

The velocity of a river is a measure of the speed at which the water travels along the channel.

My predictions for my key questions are that:

1. The bed load will start off large and angular at the source (this may be due to the river vertically eroding to reach equilibrium, which leads to the degradation of slopes from weathering and mass movement causing rocks to fall into the channel) and get smaller and more rounded downstream.

2. The change in the bed load will be partly due to an increase in velocity downstream, which will increase hydraulic action on the bed load, eroding it in size and angularity. A higher velocity downstream will also increase the process of attrition, which occurs when the rocks knock into one another, which causes them to erode.

It will be interesting to compare my results to the Bradshaw model. This model shows the characteristics that rivers usually follow from source to mouth, based on data from rivers from all over the world.

The model shows what happens to different variables of a river downstream. Some increase and some decrease. I will compare my data to what the model states about velocity and load size, and see if they agree.

The River Lemon

The River Lemon is situated in South Devon. Its source is called Lemon head and is situated in Dartmoor National Park. The River Lemon is a tributary of the River Teign, and meets it at the Teign estuary in the town of Newton Abbot. The Lemon is quite a small river at 16km long. The Lemon has a stream order of 3. At Dartmoor, where the Lemon's source is, the bedrock is made from hard, impermeable granite. Granite is very difficult to erode, and as a result, the river has not reached its graded long profile. It is still trying to erode away the granite, as this picture of the long profile shows.

Near the source, it is not a smooth curve. Further down the river the bedrock changes to softer rocks such as slate, and so the curve is a smooth one. Other factors in Dartmoor that affect the river Lemon are the high levels of precipitation and lack of trees. The consequences of this are that when there is a precipitation event, the water enters the river very quickly because water cannot infiltrate through the granite so there is high runoff, and no water is intercepted by large vegetation. So on a hydrograph, the lag time is very short.

As a result of these factors, flooding on the River Lemon is an issue, especially at Newton Abbot, where there are two rivers. In 1979 high rainfall on Dartmoor contributed to flooding on the Lemon. The culvert in Newton Abbot was too small to cope with the amount of water and ï¿½3. 6 million worth of damage was done. In 1982 a dam was completed on the Lemon, called the Holbeam dam. This dam reduces the water flow when there is danger of a flood, and an adjacent field is flooded. When there is no flood risk, the river is allowed to flow normally.

The five sites that I studied on the lemon were:

? Lemon head in Dartmoor, where the river had just started and the channel was very small

? Pinchaford woods, where some management had been implemented using large boulders, and some deforestation had occurred on the slopes.

? Bickington, which flowed through woodland

? Above Kester brook and below Kester brook. Above and below a confluence of the Lemon and another stream. This part of the river flows past a field.

The sites are shown on the satellite map.

The Lemon is a good river to study because little management has taken place, it flows through a range of geology and landscapes, it is not very polluted, and for the most part does not flow through any large urban areas. Although it is small, it should show the same patterns and processes as other rivers do.

Key question one: How does the bed load change downstream?

Downstream, two aspects of the bed load of the River Lemon change: the angularity and the size.

First I will address the change in angularity of the bed load downstream.

My prediction for this question was that near the source, there would be an abundance of angular rocks, further down the channel they become less angular and towards the source the rocks would be very rounded.

The change in angularity downstream is shown in the bar graph (figure 1). The graph shows the percentage of rocks found in each category of the Powers Index, measuring rock angularity, at each site.

The data from the graph shows that from site one (near the source) through to site five (near the mouth), the percentage of very angular, angular and sub-angular rocks decreases. The percentage of sub-rounded, rounded and very rounded rocks increases. At site one, the largest group of rocks is angular (47. 5%), and the smallest group of rocks is very rounded (0%). At site five, the largest group of rocks is rounded (50%), and the smallest group is very angular (0%).

This is the correlation I would expect. Near the source, rocks fall in from the surrounding slopes, and the channel is small and has little energy to erode the bed load and make it more rounded, so angular rocks predominate. Towards the mouth, the channel is larger and has more energy to erode so the bed load becomes rounded. There were some unexpected results in the data. At site one, only 13. 11% of the rocks were very angular, the second smallest group. So near the source I expected there to be an abundance of very angular rocks. In addition, the reduction in the percentage of sub-angular rocks downstream was not regular, in sites three, four and five, the percentage is quite similar. A possible explanation for anomalies in the results is that these results are down to opinion of which rocks fitted into which category, not measured using a more formal method. Overall the trends are good, the graph shows that bed load becomes more rounded downstream. This matches my prediction.

Now I will refer to the change in size of the bed load downstream.

My prediction for this was that towards the source of the river, the diameter of each piece of bed load would be large, and it would get smaller and smaller further downstream.

The results are shown in the scatter graph (figure 2). The graph shows the average diameter of each piece of bed load at each site.

The graph shows that from site one to site five, at each site, the diameter of the average piece of bed load decreases. This is what I would expect. Towards the source, the river has little energy to erode the large rocks that fall into the channel and make them smaller, towards the mouth there is more energy to do this. In addition, near the source of the River Lemon, the rock is made of granite, which is very difficult to erode, another reason why near the source the rocks in the bed load are larger. Further downstream the rock changes to types that are easier to erode such as slate. What is shown in the graph is quite a clear correlation and there are no hugely anomalous results. Although, the bed load does not decrease a vast amount, the range is only 2. 6cm. That could be attributed to finding the mean of sixty pieces of rock at each site. Between site one and site two, the average size decreases by only 0. 05cm. This could be attributed to the large rocks that scattered site two from a type of river management. Unusually large rocks could have affected the average.

Although a correlation does appear to exist, a way to see how reliable the correlation is to do Spearman’s rank correlation test. This is an equation to find out if the null hypothesis can be rejected (in this case the null hypothesis being that bedload size does not decrease downstream). The equation to do this test is:

n

diameter

rank

site

rank

d

dï¿½

1

6. 7583

5

1

1

4

16

2

6. 7116

4

2

2

2

4

3

5. 7383

3

3

3

0

0

4

4. 523

2

4

4

-2

4

5

4. 13

1

5

5

-4

16

This table is used to calculate the equation.

n is the number of pairs. First the data for bedload diameter is put down and ranked from the smallest to the largest. The same is done for the sites (distance from source). d is the subtraction of the bedload diameter's rank number from the site's rank number for each row. This is then squared. Next, the sum of the numbers in the dï¿½ column is calculated and multiplied by six (6? dï¿½ = 240). Then the n number is cubed, and the n number is subtracted from that (nï¿½-n = 120). 6? dï¿½ is divided by (nï¿½-n), and the result taken away from 1 (1-2= -1). This gives the answer (rs) which is compared to the significance table.

n

10% significance level

5%

2%

1%

5

0. 9

1

1

10

0. 564

0. 648

0. 746

0. 794

20

0. 377

0. 45

0. 534

0. 591

If rs is greater than or equal to the critical value for each number of pairs, then the null hypothesis can be rejected. At the 10% significance level, it means there is a 90% probability the results did not come about by chance.

At 1% significance level there is a 99% probability the results did not come about by chance. In this case the rs value is -1. The fact that is a minus can be ignored when comparing it to the table. The critical value for 2% significance level is 1. This means I can reject the null hypothesis, and the correlation between bedload diameter and distance downstream on the River Lemon is very strong and very reliable. My prediction was proved right.

Overall the graph shows a sufficient correlation, it is not a strong one, and would be better if it had more data points than five. The results of this graph support Bradshaw’s model, which shows that, from source to mouth, the size of the river’s load decreases. Bed load forms part of a river’s load.

To conclude, I feel that my data has shown sufficient correlations and answered my key question. My findings match the predictions I made in the introduction.

Key Question Two: Is there a correlation between river velocity and the size and angularity of the bed load?

The aim of this key question was to find out if the changes in the bed load downstream (angularity and size) are affected by the velocity of the river. To show this data, I made two scatter graphs: one to show the correlation between bed load angularity and velocity (figure 3), and one to show the correlation between bed load size and velocity (figure 4)

Figure 3 shows the average velocity on the y axis, and the total angularity for each site (by assigning each angularity category with a number and making a total for each site) on the x axis. I have labelled each dot representing each site. By looking at the graph, it is not easy to see a distinct correlation. The data points do vaguely fit around the line of best fit, but not strongly. The graph indistinctly shows that the rounder the rocks, the higher the velocity. The data points are arranged in a curve. It is easy to see the angularity reducing from site one to five, but the velocity seems to rise until site three, and then fall again. This could have been because site five was just after a confluence of the Lemon and another stream. The meeting of the two rivers could have caused a ‘ pooling’ effect and reduced the velocity of the Lemon. To see if a correlation exists, I shall do Spearman’s rank correlation test.

n

velocity

rank

angularity

rank

d

dï¿½

1

0. 051

1

276

5

-4

16

2

0. 125

2

259

4

-2

4

3

0. 222

5

194

3

2

4

4

0. 205

4

91

2

2

4

5

0. 18

3

56

1

2

4

6? dï¿½ = 192

nï¿½-n = 120

1-6? dï¿½ ï¿½ (nï¿½-n) = -0. 6

The significance table shows that -0. 6 is below the critical value, and I cannot reject the null hypothesis. The correlation between velocity and bed load angularity on the River Lemon is not reliable. My prediction was not overwhelmingly proved right.

Figure 4 shows the correlation between velocity (y axis) and rock diameter (x axis). Again, the correlation is hard to see. The dots arrange around the line of best fit only very loosely. The graph imprecisely shows that the smaller the rocks, the higher the velocity. Although the correlation is undermined by the irregularity in the velocity data, that the velocity reduces after site three. To check that the correlation is acceptable and that I can reject the null hypothesis that there is no correlation between velocity and bed load size, I shall do Spearman's rank correlation test.

n

velocity

rank

Bedload size rank

d

dï¿½

1

0. 051

1

6. 7583

5

-4

16

2

0. 125

2

6. 7116

4

-2

4

3

0. 222

5

5. 7383

3

2

4

4

0. 205

4

4. 523

2

2

4

5

0. 18

3

4. 13

1

2

4

6d = 192

n-n = 120

6d n-n = 1. 6

1-1. 6 = -0. 6

-0. 6 is lower than the critical value for five pairs at the 10% significance level, so I cannot reject the null hypothesis. This means that there is no strong link on the River Lemon between velocity and bed load size. My prediction was not proved entirely true.

To conclude, my data shows that on the River Lemon, there is no reliable link between velocity and changes in the bed load downstream. I do not think my key question was answered sufficiently.

Conclusion & Evaluation

The aims of my environment investigation were

1. To find out how in what ways the River Lemon’s bed load changed downstream

2. To find out if a correlation existed between river velocity and the size and angularity of the bed load

For question one, I think that my research was successful.

The angularity changed downstream in the pattern I predicted: Towards the source, more angular pieces of rock dominated, towards the mouth, more rounded rocks predominated. There were six categories of rock angularity, and the percentage of the three more angular ones decreased downstream, and the percentage of the three more rounded ones increased downstream. There were small anomalies in the data, there were more rounded rocks in site one than site two, and more very angular rocks in site four than site three. I think that the bar graph I used was the most compact and easy way to show the data. Problems with the data collection were that the results were measured with opinion, sometimes rocks were hard to categorize. Overall the trend was clear and matched my prediction.

The size of the bedload also changed downstream in the way I predicted: It started off fairly large, and gradually became smaller downstream. The data points are all close to the line of best fit. The Spearman's rank correlation test showed a strong correlation in the results. Although one limitation of this test is that anomalies such as the similarity of size between site one and two are not taken into account as the results are ranked in order to calculate the result. Perhaps this test would have been more useful if I had used more data points. The difference between the rock size for site one was not much different to the rock size for site five. This may have been due to finding the mean of sixty rocks of a range of sizes, and unusual sized rocks could have affected the average. It could have also been due to the inclination to pick up larger rocks (that are easier to handle) instead of smaller rocks when sampling.

For question two, the results were inconclusive.

I expected that the reason for the bed load becoming smaller and more rounded downstream would be due to the increased velocity and therefore increased hydraulic action on the bedload, eroding it away. This is expressed in the Bradshaw model, which states that velocity increases downstream, and load size decreases. What I found was only a vague correlation for both rock angularity and size, that increased velocity meant smaller and more rounded pieces of bedload. But the data points were scattered only loosely around the line of best fit. I think the correlation was so unclear because velocity decreased after site three, making data points appear to curve.

The velocity irregularity could be due to the River Lemon having a confluence with another stream just before site five. This could have created a ‘ pooling’ effect of the two rivers and reduced the Lemon’s velocity. I think that creating a number for each angularity category and finding the average was a good way to show the angularity data in a scatter graph. The Spearman’s rank correlation test showed that there was no strong correlation, and more than a 10% chance the results came about by chance. Although, because there were only five pairs, the result was not very accurate, it was the same rs value for both correlations. In the future I could have used more data points and a trend might be clearer. The flowmeter was a good way to measure velocity, but at site one, the channel was so small that the flow could not be measured very accurately.

If I were to redesign the project I would change certain aspects. I would sample the bedload by taking it out with a shovel, and find the median rock size, as I think this would be more representative of the overall trend at each site. I would use data from more sites on the river, maybe seven or eight. I would have the sites be equally spaced out along the river, the first site being at the source, and the last site being at the mouth. In my investigation, the last site was not very near the mouth of the river, and therefore does not show the extent to which the bedload changes.

Overall I think my investigation has been only partially successful. I aimed to show that velocity increased downstream which reduces the size and angularity of the bedload. What I found was that the correlation between velocity and bedload was not as strong as I thought it would be. The bedload is an important aspect of the river as it affects both the velocity and efficiency of it. The river Lemon does have some problems with flooding, and these problems stem from Dartmoor, where there is a large bedload of hard granite. One possible way to reduce the flood risk is to dredge the channel of sediment, making it deeper and therefore having a larger carrying capacity to cope with flooding, and so reducing the flood risk to settlements downstream like Newton Abbot. Dredging makes rivers more efficient and is cheap, but requires regular maintenance and can have a negative impact on any species living there. Studying rivers is important for humans to understand them and live in harmony with them.